Issued February 10, 1909.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—BULLETIN No. 55.

MILTON WHITNEY, Chief.

SOILS OF THE UNITED STATES,

BASED UPON THE WORK OF THE BUREAU OF SOILS TO JANUARY 1, 1908.

BY

MILTON WHITNEY.

Part I. Results of Recent Soil Investigations.
Part II. Classification of the Soils of the United States.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., August 13, 1908.

SIR: The accompanying article, entitled "Soils of the United States," is composed of two parts. The first part consists of seven lectures covering the activities of the Bureau of Soils in the field and in the chemical and physical laboratories for the last nine years and discusses in a general way the most notable achievements during that period, coupled with suggestions for further research in the fundamental field of soil study. Each of these lectures being in a measure complete in itself, no effort has been made to give Part I the unity of development to be expected in a monograph, and certain duplications of statement occur which have been allowed to stand because necessary to the proper elucidation of the subjects considered under the main titles.

Part II consists of descriptions of the soil provinces, soil series, and soil types, the last particularly from the standpoint of crop adaptation. The extent and the distribution of the soils of the United States are also shown, and the whole gives the complete classification of soils up to January 1, 1908.

I have to recommend the publication of this work as Bulletin No. 55 of the Bureau of Soils.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

PART I. RESULTS OF RECENT SOIL INVESTIGATIONS.

ILLUSTRATIONS.

FIGURES.

PLATES.

SOILS OF THE UNITED STATES.

PART I. RESULTS OF RECENT SOIL INVESTIGATIONS.

NATURE AND PROPERTIES OF THE SOIL.

Since the soil is a complicated system of four distinct classes of material, of which the constitution and properties are not thoroughly understood, and since these materials interact one upon another and at the same time are also acted upon by at least nine agencies, of the functioning of which agencies much is yet to be found out, the subject of soil investigation is one of the most intricate and difficult that has ever been undertaken. The subject of soil investigations as a laboratory study has been divided for convenience into soil chemistry, soil physics, and soil physiology, but the separation of these several fields is poorly defined and must be arbitrarily made, and can not be followed in a general paper of this character.

The soil in place in the field and in condition to grow plants consists of—

Minerals.
Water.
Soil atmosphere.
Nonliving organic matter.

These materials react on each other and in so doing affect the conditions for plant growth to such an extent that certain rather definite proportions must be maintained for successful crop production.

There are certain agencies common to soils which also react on or affect each other and the soil material. These are—

Plants.
Bacteria.
Molds and fungi.
Enzymes.
Earthworms, etc.
Radiant energy.
- Light.
- Heat.
- Electricity.
- Various other forms of radiant energy recently discovered.

SOIL MATERIALS.

MINERALS.

The grains of sand, silt, and clay contained in all soils consist of a large number of minerals, such as are also common to and make up the bulk of all common rocks, and, in addition, of very insoluble decomposition or alteration products. If a small sample of soil is thoroughly washed by decantation, being repeatedly pestled or violently shaken in a bottle with the water so as to loosen all the grains and wash out the fine material, or if it is merely acted upon by a dilute acid to remove the highly colored iron compounds, the variety of color and of form to be seen with the naked eye or with a hand lens will indicate the variety of mineral constituents. The common rock-forming and soil-forming minerals are—

Quartz.
Limonite—Turgite series.
Hematite.
Kaolin or kaolinite.
Feldspars.
Micas.
Apatite.
Hornblendes.
Pyroxenes.
Chlorites.
Tourmaline.
Rutile.
Calcite.
Dolomite.
Selenite.
Zeolites.

These minerals contain potash, phosphoric acid, lime, magnesia, and other mineral plant food. The way these plant food constituents go into solution and the way the concentration of the solution or the soil moisture is maintained at all times nearly constant and sufficient for plants is one of the most interesting subjects that has been investigated by the bureau. It is fundamentally important and has completely changed the point of view of soil investigators, leading to important lines of work which are clearing up the very intricate problems of soil fertility. The investigations referred to are on the solubility and absorptive power of the soil components.

SOLUBILITY OF SOIL MINERALS.

The common soil minerals given in the above list have been considered and are in fact very slightly soluble. They are of a similar order of solubility as ordinary glass, which in household use and even too often in our laboratories, until in recent years, we have considered practically insoluble. But it was found that in the finely divided condition in which these minerals exist in the soil, where an enormous surface is presented upon which the water acts, the solution quickly becomes saturated with the mineral plant food elements, and that the 25 parts of potash per million of solution and the 10 parts of phosphoric acid which would be dissolved in this water is ample for the needs of the plants, provided this concentration is maintained as the plants feed.[a]

The solubility of each mineral in the water and in connection with a mixture of so many different kinds of minerals as are found in soils makes the concentration and composition of the solution nearly the same for all soils. Finally, as the mineral plant food constituents are withdrawn by the growing plant the minerals readily give up to the solution sufficient to restore the saturated condition with respect to the various minerals. So long as there remains in the soil any of the solid mineral the amount that goes into solution and the influence of this on the solubility of other minerals would be quite independent of the quantity of the mineral in the soil, except for disturbing influences which will be discussed later.

An illustration or two may make this clear. If a teaspoonful of water is poured into a barrel of salt sufficient salt dissolves to make a saturated solution. If a cup full of water be then poured in, sufficient salt dissolves to saturate this also, and so while any solid salt remains the solution will be of constant concentration, regardless of the amount of salt or the amount of water. Salt is so very soluble in water, however, that one part of water will carry in solution over one-third of its weight of common salt, so that it would not take any very large quantity of water to entirely dissolve the barrel of salt, but in the combinations in which the minerals occur in the soil the soda and potash are so very insoluble that it requires about 1,000,000 parts of water to bring into solution 25 parts of potash.

Two calculations will show how this applies to the soil. With 1,000,000 pounds of water in contact with 5,000,000 pounds of soil the solution will contain 25 pounds of dissolved potash, although the actual amount of potash in the soil may vary from 30,000 pounds in one soil to 120,000 pounds in another.

Parts per million of potash and phosphoric acid in solution with a constant amount of water on a fixed quantity of soil of various compositions.

Constituents.	I.	II.	III.
Water	1,000,000	1,000,000	1,000,000
Potash, p. p. m.	25	25	25
Phosphoric acid, p. p. m.	10	10	10
Total soil	5,000,000	5,000,000	5,000,000
Potash reserve	30,000	60,000	120,000
Phosphoric-acid reserve	5,000	10,000	20,000

If in another case a soil of constant composition is moistened with successive quantities of water the concentration of the solution will

[a] The solubility and hydrolysis of soil minerals have been fully discussed in Bulletin 30 of this Bureau.

be the same with each amount of water, although the actual amount of potash dissolved from the soil will vary with the amount of water.

Parts per million of potash and phosphoric acid (a) in solution, and (b) based on dry weight of soil with varying amounts of water and a constant amount of soil of constant composition.

Constituent.	I.	II.	III.
(*a*) Solution:			
Water	1,000,000	500,000	250,000
Potash, p. p. m	25	25	25
Phosphoric acid, p. p. m	10	10	10
(*b*) Dry soil:			
Total soil	5,000,000	5,000,000	5,000,000
Total potash	30,000	30,000	30,000
Total phosphoric acid	5,000	5,000	5,000
Dissolved potash	25	12.5	6.25
Dissolved phosphoric acid	10	5	2.5

Finally, the composition of three soils is given, showing the amount of potash in reserve, the amount of potash in the solution, and all other mineral material going to make up a million parts of soil. The same thing is shown for the phosphoric acid.

Potash and phosphoric acid dissolved in the moisture of a soil containing 20 per cent of water.

Constituent.	I.	II.	III.
(*a*) Solution:			
Potash in solution	5	5	5
Potash in reserve	6,000	12,000	24,000
Other soil material	993,995	987,995	975,995
Total	1,000,000	1,000,000	1,000,000
(*b*) Dry soil:			
Phosphoric acid in solution	2	2	2
Phosphoric acid in reserve	1,000	2,000	4,000
Other soil material	998,998	997,998	995,998
Total	1,000,000	1,000,000	1,000,000

The initial rate of solution is so rapid that in a very short time after the water is mixed with the soil the solution is nearly saturated and will take up but very little more if it is left in contact for days or months.

If this potash is removed by plants, no sensible change in concentration takes place, as more immediately goes into solution. This can be illustrated in a very beautiful way with a special form of porous cell containing a small quantity of soil. By electrical endosmose, a slow stream of water drops continuously for months, carrying measurable quantities of potash; and phosphoric acid collects in the other compartment.

That the potash, phosphoric acid, and other plant food constituents resulting from the solubility of these minerals are available to plants, without any further change due to the weathering and decomposition of the minerals, as we formerly thought necessary, can be proved, as has been done repeatedly by growing plants to maturity in solutions so prepared.

ABSORPTION.

There is, however, another very important property of solids in contact with liquids which tends to control the concentration of the soil solution and to prevent undue waste of material, namely, the power the soil grains have of absorbing and holding on to dissolved salts. On the surface of a mineral particle moistened with water there is a pressure, which has been variously estimated at from 6,000 to 25,000 atmospheres, and which may be conservatively estimated as at least 10,000 atmospheres, or 150,000 pounds per square inch, acting at an inconceivably small distance from the solid surface. Ten thousand atmospheres or 150,000 pounds per square inch is approximately 15 times the muzzle pressure of a 12-inch gun (fig. 1). Under this surface pressure the concentration of the solution is enormously increased in the surface film, and chemical changes and reactions may take place which are impossible to bring about under laboratory conditions with solutions in beakers.

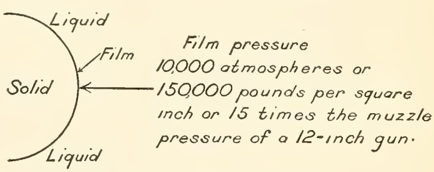


FIG. 1.—Film pressure.

An example will at once illustrate the power and significance of this absorptive action. A solution of a very soluble potash salt was passed very slowly through some soil until the soil had absorbed 4,000 parts per million of its weight of potash, after which fresh water was passed through the soil, and the solution draining off was found to have the same concentration as before the soluble potash salt was introduced. The same thing occurred with a soluble phosphate. That this may not be a chemical change is indicated by the fact that certain organic dyestuffs dissolved in water will be similarly withheld by soils and will not be given up to fresh water, but will readily come out again by passing alcohol through the soil.

This absorptive power varies greatly with different soils and with different minerals, and varies for different substances or parts of substances. It is stronger for potash than it is for chlorine, and a weak solution of potassium chloride passed slowly through a soil comes through acid with hydrochloric acid, the soil having retained more of the potash than of the chlorine. If some silver nitrate is passed slowly through finely divided charcoal, the salt is decomposed by this selective absorption, some free nitric acid comes through, and small spangles of silver can be seen in the charcoal.

On account of this absorbing power it is altogether unlikely that fertilizers applied to soils in ordinary amounts will noticeably increase the concentration of the free water in the soil, as appears from the diagram (fig. 2), in which the curve representing absorption rises in practically a straight line until a high concentration is reached, when more and more of the salt goes into the free solution. The line *F* marks the possible increase of concentration represented by an ordinary application of fertilizer, which is seen to be far below the absorptive capacity of the soil.

As there must always be a certain distribution between the amount of mineral matter absorbed and the quantity in the free solution,

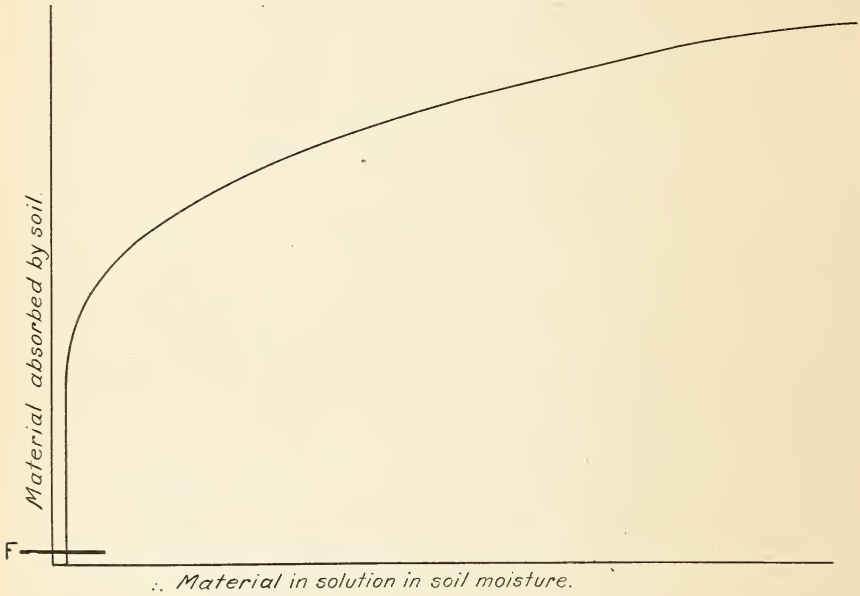


Fig. 2.—Absorption of salts by a soil.

and as this under ordinary conditions leaves about 25 parts per million of potash in the free solution, with an enormous reserve supply in the minerals themselves, it can readily be seen what an important factor this absorption is in regulating the concentration of the soil moisture. In attempting to study the relation of alkali soils to vegetation, an artificial mixture was made by adding 1 per cent of sodium carbonate to one of our eastern soils. No appreciable amounts of the salt could be found in an aqueous extract of it made subsequently, and plants grew well in the soil, whereas natural alkali soils showing 0.20 per cent of this salt are fatal to most plants.

It has been said that with the enormously high pressure on the surface film chemical changes may take place in soils which are not possible in the laboratory, and there is evidence to indicate that under ordinary conditions of temperature minerals which have not been formed in the laboratory actually form in the soil. The material for these minerals may come from great distances or from great depths, as a result of the slow but profound movement of ground waters. Too little consideration has been given to this subject of the range of movement of soil moisture. It is of the utmost importance in considering the permanency of soil fertility.

TEXTURE OF SOILS.

Having discussed the solubility of the minerals and their absorptive powers as a means of supplying the mineral plant food in the proper concentration for the use of crops, we will now consider the size of the mineral particles as determining the soil texture, which influences alike the relation to moisture and the chemical changes taking place through oxidation, especially of the organic bodies in the soil. The texture of the soil is expressed in the mechanical analysis by a separation into seven grades, the sizes of which are arbitrarily fixed. The results of the analysis show the percentages of sand, silt, and clay.

The texture determines to a large extent the relative power of soils to hold water. Under equal conditions of depth and exposure coarse-grained soils hold less moisture and more air than fine-grained soils, so that taken as a whole they contain less solution, and consequently a smaller quantity of nutrient material in solution. They also have generally a lower absorptive capacity and presumably permit a much more rapid and at times possibly an excessive oxidation.

When, aside from texture, the physical and chemical properties of the soil and its method of formation are alike, we have what we call a soil series, extending from the coarse gravelly or sandy soils on the one side to the finer silt and clay soils on the other, and in such a series the texture of the soil determines the distribution of crops.

It would be a comparatively simple matter to compare and classify soils according to the mechanical analysis or texture, but this standard alone is not sufficient, and the problem is in reality a very difficult thing, for in working out the relation of the soils to crops other factors enter which must be recognized in the correlation. One of the most important of these is the structure or the arrangement of the mineral matter. In some soils the mineral particles have a granular arrangement of flocculated masses, making the soil loose and porous. In others the grains appear to have no such coherency, but exist in a compact form, making the soil hard and compact. We also have the gumbo and adobe soils and others that are exceedingly plastic. Then, again, the amount and character of the organic matter influences not only the productive capacity of the soil, but its adaptation to crops, while the color of the soil has to be considered as indicative of certain obscure chemical or physical relations that influence the adaptation and productivity. The drainage features also come in, often with material influence on the organic constituents, on the aeration, and on oxidation processes. These factors all tend to make the correlation of the soils and the determination of their proper utilization and management a complicated matter. There are also differences shown in the relation of soil types to crops under different climatic conditions, the reasons for which, while fairly well understood from our recent investigations, would hardly find a place in a paper of this kind.

WATER.

As soon as water is introduced into the soil, whether by rain or by irrigation, it obeys certain physical laws which tend to bring about new equilibrium conditions. The soil moisture, with its dissolved mineral substances, forms the nutrient solution for the support of plants. We have seen how this material is obtained and how the concentration of the solution is maintained. We have now to see how this solution moves in the soil to supply the needs of the plant, which is fixed in its position and can not move around in search of water, as most animals can. Water may be contained in the soil in four different ways or conditions, in each condition exhibiting markedly different physical properties and peculiarities. These are combined water, or water of hydration, hygroscopic water, capillary water, and gravitational water.

CAPILLARY WATER.

The distinction between capillary and gravitational water in soils is by no means closely defined. Briggs [a] gives this definition:

> Gravitational water is that portion which is in excess of the amount which the soil is able to retain under existing conditions, and is consequently free to drain away. The capillary water is that part which would be retained in the capillary spaces under these conditions and which is capable of movement under capillary action. The hygroscopic water is that found on the surface of the grains, which is not capable of movement through the actions of gravity or capillary forces.

The capillary water is the principal source of supply of water to plants, and of the supply of mineral plant food constituents also, and is probably the seat of important biological changes in the soil. On the other hand, it undoubtedly plays an important part by carrying material from place to place in the soil and possibly in other ways.

---

[a] Bulletin No. 10, Bureau of Soils, United States Department of Agriculture.

The relative amount of capillary water held by soils, other things being equal, is dependent upon the texture or size of the mineral particles and their arrangement, the depth of soil and facilities for drainage, and the amount, kind, and conditions of the organic matter. There is what we call the optimum or best amount, which varies with each soil. It ranges from about 20 per cent of the weight of dry clay soil and very much more for peat and muck soils to 4 per cent for some sandy soils. An important investigation, just completed, indicates that this optimum is a critical point for several of the important properties of soils.

At about 80 per cent of the optimum occurs the drought limit, at which point plants, unless especially protected by their structure as certain desert plants are, suffer through loss of turgidity and finally collapse, probably not because they are unable to obtain water from soils of that water content, but because the root removes water more rapidly from the surrounding soil than the water moves in the soil. Certainly seeds and probably plants have as great, if not greater, absorptive power for water than soils have. Air-dry seeds containing on an average about 14 per cent of water, if crowded into an equal weight of soil of optimum water content, after two days will leave the soil in an air-dry condition. A lima bean absorbs something over 100 per cent of its weight of water during germination. A single large lima bean introduced into a soil with the water content at or near the drought limit will completely air dry a thin layer of soil adjacent to its surface, yet fail to germinate for lack of sufficient moisture, although the soil as a whole contains as much as 15 per cent of its weight of water. This formed a very interesting investigation by the Bureau reported in Bulletin 23, in which it was shown that somewhat below the optimum the rate of movement becomes so slow as to be almost negligible. There are interesting lines of research still in all these fields.

OTHER FORMS OF WATER.

The water of hydration, which is chemically combined with the minerals, probably in the state of a solid in the mineral, is apparently of little direct use to plants in humid climates. We know, however, that under certain conditions dead and decaying organic matter does avail itself of the oxygen of the minerals, reducing the degree of oxidation, and there is reason to believe that it may also dehydrate certain minerals. Indeed, it has recently been suggested that certain desert plants may, under certain conditions, avail themselves of water gathered from such a source. Under certain conditions water so held may play an important, but, under ordinary conditions, a minor part in the soil economy through the chemical changes incident to the decay of organic matter. The question certainly deserves more study than it has had.

The hygroscopic moisture is that which adheres to an air-dried soil. Owing to the enormous force with which it is held by the soil grains and the high concentration of dissolved mineral salts due to this stress, it undoubtedly plays an important part in the chemical changes which take place. It has long been known that soils are particuarly productive after a long and excessive drought, and this is possibly due to the destruction of certain organic bodies in the high concentration of the surface film. Under ordinary atmospheric conditions loams and clay soils contain as much as from 4 to 8 per cent of their weight of hygroscopic moisture and soils rich in organic matter frequently much more than this.

The gravitational water marks an excess for most soils and is harmful rather than beneficial to most crops. However, in certain light sandy soils in low-lying position the beneficial effects of the retention of water, which in other positions would be harmful as gravitational water, is seen.

EVAPORATION.

At and above the optimum water content evaporation from soils is relatively very rapid. Below this point there is a marked change and the evaporation becomes very much slower and to a large extent takes place within the soil, instead of from the surface, the vapor coming out by the slow process of diffusion. A dry surface mulch, in which the capillary movement of water is exceedingly slow, conserves the moisture below by protecting from surface evaporation. Evaporation within the soil may take place at considerable depths and is a much more important factor than was formerly supposed.

SOIL ATMOSPHERE.

The soil atmosphere is considerably richer in carbonic acid gas and nitrogen than is the atmosphere above the soil. This results mainly from the consumption of oxygen in the oxidation of organic matter and the consequent liberation of carbon dioxide, which tends to diffuse out and to come into equilibrium with the free atmosphere. The diffusion process is slow, especially at considerable depths, and with many crops cultivation is necessary to secure more perfect aeration. So acute is the need of oxygen in some soils and under certain conditions of compactness and lack of drainage that the decaying roots and other forms of organic matter may deoxidize the soil minerals, as is apparent from the change of color of the soil.

NONLIVING ORGANIC MATTER.

Less is known about the nature of the organic constituents than about the mineral constituents of the soil. All kinds of animal and plant remains and their decomposition products are liable to occur in the soil. The great problems of chemistry of the soil will probably be found in a study of its organic constituents.

The color of a soil is not a sure indication of the amount of organic matter which it contains. Some characteristically black soils have less organic matter than some of the red or yellow soils. This appears to be a question of the condition of the organic matter, resulting from different processes of decay. In some soils it breaks down into a black product, the kind of material which we recognize by the undefined term "humus." In other soils the material is of a much more neutral tint or even colorless. Such soils usually yield, however, an intensely black solution when extracted with a dilute alkali, especially on standing in contact with the air.

A high degree of lasting fertility is usually associated with black soils, and they are usually considered more productive than yellow, red, or brown soils, but many notable exceptions to this rule are known. The trouble often experienced in obtaining satisfactory crops on newly reclaimed swamp land and fresh muck suggests itself as an example; also the high productive capacity of the brown or red soils of the Hagerstown series of central Pennsylvania and the Indian red soils of the Penn series in New Jersey. The density of black, as also the shade of color of the mineral matter of the soil, will often indicate to a trained observer differences in soils which mark decided differences in crop adaptation. The reason for this forms one of the most interesting fields of investigation and one of great economic importance.

AGENCIES IN SOIL FORMATION.

PLANTS.

In view of the evidence presented by recent investigations of the Bureau it can no longer be doubted that plants produce waste products which, unless removed or altered in the soil, may become harmful or toxic to other plants of allied species. Organic bodies highly toxic to wheat have been separated from the soil in which wheat has recently been grown, though the soil did not contain these bodies before the wheat was planted. Wheat immediately replanted upon the soil which was shown to contain these products made only half the growth that a first crop made, while some of the organic matter introduced into an otherwise suitable nutritive solution likewise impaired the growth of wheat. The incompatibility of numerous plant associations, for example, weeds and crops, grass and trees, we now believe to be due to the excretion of one plant inhibiting the growth of another, unless the conditions in the soil are favorable to the rapid removal or change of the substances so formed. The mode of growth of roots and their corking over show us how a plant may protect itself from its own excreta and why a replanted specimen of the same species grown on what must now be considered a contaminated soil can not protect itself from the excretion of the plant which has recently occupied the spot. In the fact that some varieties of plants appear to be not at all affected by the excreta of other plants, and may even help to destroy such excreta, we have the reason for the beneficial effects of rotation of crops.

BACTERIA.

The great scavengers of the soil are those bacteria whose office seems to be to work over and change the organic remains of plants and animals. Under certain soil conditions forms of bacteria thrive, which, through their products, change and purify the soil while the crop is growing and after the crop is harvested. Under other conditions, however, other forms of bacteria flourish, and bring about the production of substances very toxic to plants. Such conditions probably prevail in the subsoil, and this explains the injurious effects often seen in turning up too much of the subsoil in plowing. Association of certain forms of higher plants and associations of bacteria are killed by accumulations of their own excreta, and bacteria are influenced by the excreta of other forms, as the higher plants are.

MOLDS AND FUNGI.

The action of molds and fungi in the soil may frequently be beneficial to plants, but it has been shown that their products or excreta are often very detrimental and toxic. This seems to be the explanation of "fairy rings," and recent investigations appear to show other cases of toxic products in the soil arising from the action of molds on the living or dead organic matter of the soil. Associations of molds and bacteria are generally incompatible. The humus extracted from soils appears to be sterile to bacteria, but is readily attacked by molds under conditions suitable for their growth.

ENZYMES.

Enzymes are undoubtedly essential in the fermentation of organic matters and the production of new organic compounds. They play a very important part in the fermentation of manure and the preparation of it for its best effects on certain soils. They also play an important part in the decay of green manures in the soil. Finally, the characteristic reactions for enzymes may be obtained from many soils. Enzymes are active oxidizing or reducing agents, but what part they play in the sanitation of the soil besides the functions indicated is not clearly understood, as the subject has not been specifically studied.

RADIANT ENERGY.

Very little recent progress has been made in the study of the various forms of radiant energy upon the soil or upon the problems of soil fertility. Heat, it is known, has an important effect upon soil changes, but how and to what extent it influences the soil and with what results is not clearly understood. It has been suspected that various forms of electrical energy may be effective also in the economy of the soil, and recently it has been suggested that the various recently discovered forms of radiant energy may have some part to play, but how or to what extent is not even conceived at this time.

FERTILIZERS AND MANURES.

Organic manures are active oxidizing or reducing agents according as they give oxygen to or take it from other bodies, in either case tending to break down into the simplest compounds and so to aid in the destruction or change of the organic matters in the soil. In this way they operate to improve the sanitary conditions of the soil. While it appears reasonable to expect that the mineral matter contained in the manure may benefit some soils, experiments in which the organic matter and mineral matter of the manure were separated indicate that the main beneficial effect is derived from the organic portion. Nitrogenous organic material has a beneficial effect on soils only when decomposition proceeds in a certain way under certain favorable conditions. Other plants having as high a mineral content do not in their decay have so marked a beneficial effect on the soil. The effects of manure and green manure on the soil may be deleterious to plants during the initial stages of decay, but become beneficial after a few days' fermentation or decomposition in the soil under proper conditions.

Commercial fertilizers, as we have seen, do not increase permanently the concentration of the free moisture in the soil, but are absorbed into the film of high concentration attached to the soil grains, the seat of the most profound chemical activity. It appears that fertilizers act upon the soil rather than on the plant, but in conjunction with the plant they can often accomplish more good in improving the sanitary conditions of the soil than either the fertilizers or the plant alone, and that fertilizers do act upon and render less harmful some of the toxic organic bodies liable to be encountered in the soil. Support is lent to this view by the importance of the form of compound and the proportion of the fertilizer ingredients. All of the potash salts are not equally effective on all soils or with all plants. Some of the potash salts, as, for instance, the iodide of potash, are harmful to plants, while the chloride is generally less safe than the sulphate. The nitrate and sulphate of ammonium and the different forms of organic nitrogen used have different effects, even when used on the same soil for the same crop. The conclusion is that it is the compound or material as a whole that determines in large measure the effects which will be produced, rather than simply the amount of potash, nitrogen, or phosphoric acid which the substance contains.

These matters can now all be easily and exactly studied by methods of research recently devised, and there is no line of study more interesting or practical than those presented or any that will throw more light upon the practical methods of soil management.

THE CLASSIFICATION OF SOILS.

MATERIAL.

The basal material of the soil, as we have seen, is an aggregation of mineral particles of various sizes, ranging in the fine earth from 2 mm. in diameter to a size so small as to be hardly distinguished with the most powerful microscope. The difference of size of the particles and the different proportions of the different sizes give rise to the texture and influence the various physical properties, such as the water-holding power, the aeration, etc.

The slight solubility of the minerals and their high absorptive capacity provide in the soil moisture a dilute nutritive solution of nearly constant concentration, but of sufficient strength for the needs of plants, as far as their requirements for the mineral plant-food elements is concerned. An important point, and one which has been given too little consideration in the study of soils in the past, is the very wide distribution through them of all the common minerals and the tendency under such conditions as prevail for all chemical changes to produce the most insoluble products consistent with the nature of the material. There has been a failure to appreciate that under equilibrium conditions there is always a definite distribution between the substance dissolved and the solid substances in contact with the solution.

There are associated with the minerals of the soil various organic bodies resulting from the decay of former vegetation or excreted by growing plants which affect more or less the sanitary conditions of the soil and its healthfulness for crops. Important chemical changes must occur in disposing of this waste product to preserve the proper conditions in the soil, and in some soils such sanitary conditions are more easily maintained than in others, whether we refer to natural changes within the soils or to artificial treatment. Such chemical properties and powers appear to be associated in some way not at all well understood with the mode of formation or deposition of the soils as well as with the character of the material from which the soils have been derived.

ROCKS AND SOILS.

Soils are undoubtedly formed from the disintegration and decomposition of rocks, but rocks may also be formed from the consolidation of soils. These may again break apart into soils and be again reconsolidated into rocks. The most important fact in this connection is that all of our common rocks contain practically all of our common rock-forming minerals, though in widely varying proportions. One has but to look at a specimen of a common sandstone or shale to see the plates of mica and other forms of minerals associated with the quartz. We find the same minerals in the sandstones, limestones, and shales as in the granites, gneisses, and schists. The differences, aside from variations in the relative proportions, appear to be that one set is formed by water deposition with or without pressure under ordinary temperatures, while the other set is formed under conditions of high degrees of pressure and temperature. There are of course exceptions in the case of any pure sandstone as there are in the case of exceptionally pure forms of igneous rocks. There is a question among geologists whether what we consider the oldest crystalline rocks in the United States have not in fact been formed by consolidation under great pressure and high temperature from assorted material worked over from still older and more primitive rocks.

It is a mistake to suppose also, as we often do, that sandstones always give rise to sandy soils. Some of our most tenacious clay soils come from sandstone, as, for instance, the Penn clay from the Triassic red sandstone rock.

PHYSICAL PROPERTIES OF THE SOILS.

The most obvious of the physical properties of a soil are its texture and color, both of which indicate important soil differences influencing crops.

TEXTURE.

The texture of a soil is determined by the proportion of the different-sized mineral particles it contains. This proportion is determined by the method of mechanical analysis, in which the soil is first shaken for a long time in water to separate thoroughly the mineral particles and then the fine material washed out, this being still further divided, utilizing for the purpose the known law that different-sized particles subside at different rates. The coarser particles are separated by means of sieves with different-sized openings, and thus the soil is finally divided into seven grades, the limits of which are arbitrarily fixed.[a] From the relative proportions of these the texture of the sample is determined.

In naming a soil the texture of the surface soil and of the subsoil to a total depth of 3 feet in the humid States and of 6 feet in the arid States is taken into consideration. We have soils, therefore, with a sandy surface soil and a clay subsoil; less frequently a clay soil and a sandy subsoil. We have soils with a loam top soil and a clay subsoil, or a loam top soil and a loam subsoil. Furthermore, in the descriptions of a soil in each area surveyed the texture and character of both the top soil and the subsoil are given, so that when a soil is specifically referred to by name, as for example, the Norfolk sandy loam, the term "soil" in this sense refers to the entire profile, including the top soil and the subsoil.

In correlating soils, therefore, and deciding that the soil of one place is similar to and is to be given the same name as the soil of another place, we must take into account first of all the texture of the entire depth of 3 or 6 feet, as the case may be. In sampling soils we always keep separate, for the purpose of mechanical analysis, the top soil and the subsoil, and if the subsoil shows two phases or layers of different texture we separate these also. The experienced soil-survey man can judge very accurately of the texture of the soil material, but even his judgment, before being accepted, is always confirmed by mechanical analysis.

Where soils have a common origin and differ only in texture and are alike in color and in physical properties other than those effected by texture, they are arranged in what we call a series, having the soil generic name with qualifying textural terms. We have, for example, the Miami gravelly loam, the Miami fine sand, the Miami sandy loam, the Miami silt loam, and the Miami clay loam as prominent types in the Miami series. In this particular series we have fourteen types, and possibly two or three other types will be encountered. In the Norfolk series we have twelve types.

Other things being equal, as the texture varies the water-holding capacity of the soil will also vary, the light sandy members of the series or the sandy types holding on the average not over 4 per cent of water, while the clay members at the other end of the series will hold 20 per cent of moisture. With this difference in moisture there is a corresponding difference in the soil atmosphere and oxidation is usually much more rapid in the sandy members than in the clay members of a series.

[a] Bulletin No. 24, Bureau of Soils, U. S. Dept. of Agr.

The effect of differences of soil texture upon the adaptation of soils to crops and upon crop production is well known. For some reason which we can not yet definitely explain, under humid conditions wheat is not well adapted nor will it produce bountiful crops on the sandy members of a series. Early spring crops, such as lettuce, peas, and early potatoes, produce good yields and ripen much earlier in these sandy soils, and as a rule they are adapted to these truck crops. In the Atlantic Coast States corn comes next in being best adapted to the loam members of a series, then wheat on the heavier loam and clay-loam members, and lastly, grass on the heavier clay loams and clays. This is a general statement, to which there are many exceptions on account of modifying conditions which will be presently discussed.

In the low-lying portions of the Coastal Plains, where drainage is somewhat deficient and the capillary water content of the Norfolk sand is supplemented by a suitable amount of gravitational water, very good crops of wheat are produced if the intensive methods used in the production of truck crops be followed. In the Middle West, under the climatic conditions which prevail, corn is grown on the black clay loams and clays, while in the far West, under the climatic conditions and prevailing methods of that region, the influence of the texture of the soil is not so apparent.

Where the structure of soils differs for some natural reason, as, for example, where they run together and form a compact hard mass in a dry season, or, to take another case, maintain a loose and open structure, we know that this does influence in some way the drainage conditions, the conditions of aeration, the ease of root penetration, and in general those processes which go on in the soil and make for those sanitary and physical conditions proper for crop production. Where such differences in structure are observed, even if the texture and color of the material is the same, the soils are not put into the same series, but are placed perhaps in another series having similar structural peculiarities or for the present are thrown into a miscellaneous and unclassified group.

If the texture and structure of two soils is the same and one differs in a marked degree from the series color, and that departure is fairly constant and typical of the area covered by the soil, this soil likewise is thrown out of the series, because we have reason to know, by observation of the growing crops, that this color difference stands for a difference in the chemical changes which go on in the soil and which are necessary for the welfare of certain crops.

In the classification of soils, therefore, the texture is used to determine the place in the series; the structure and color to determine what series the soil can be correlated with.

COLOR AS INDICATIVE OF FERTILITY.

Too little attention has been given to what appears to be the influence of color, or some associated properties of the soil which determine the color, on the yield and qualities of the crop. In mapping the soils in the field there is something in the physical aspect which indicates to the soil expert that some difference will be found in the character of the crops produced or in the methods of cultivation or fertilizers required to produce satisfactory yields. The soils are mapped in the field, usually from obvious physical differences, the laboratory work being mainly to confirm the man's judgment as to texture and to investigate properties which may explain observed differences. It is not wholly a matter of the relation of the soil to water which influences him in judging of the structure, for the field classification of soils goes on in all seasons and the soils are seen in all conditions of moisture, from excessively wet to excessively dry, yet the expert can at all times tell, by an examination of the soil material, the differences in the structure and the relation to drainage, and can judge, moreover, of what can be accomplished in changing the conditions by artificial means.

Careful observation has shown that the black, red, yellow, blue, and white soils of the Coastal Plains are essentially different in their properties and in their relation to the yield and quality of crops. The soil man knows that on the red soils of the Orangeburg series, whether the Orangeburg sandy loam, the Orangeburg loam, or the Orangeburg clay, he will get a tobacco from Cuban seed which has a certain texture and a certain aromatic quality which can not be obtained from the same seed planted on the yellow soils of the Norfolk series, in adjoining fields, and under identical climate conditions. The texture of the soil in this case will influence the texture of the leaf. On the light soils of the Orangeburg series he will know that the product will be a thinner leaf and that on the heavier soils of the same series the leaf will be heavier and contain more gum, but will have the same aromatic qualities. On the yellow soils of the Norfolk series in our South Atlantic and Gulf States he will get the finest quality of wrapper leaf of the Sumatra type, without aroma, with little gum, but with an elastic texture and a bright glossy finish which can not be equaled on the red Orangeburg soils. Why the color of the soil should indicate this is not apparent. It does not seem probable that it is due to the actual difference in color or even to the differences in oxidation and hydration of the minerals which occasion the color, but to some property in the soil which determines that under similar climatic conditions the color of the one soil derived from the same material of the Piedmont Plateau, laid down so far as we know under similar conditions, shall consistently be red, while the soil of an adjoining field may be yellow. The chemical properties exhibited in the differences in color of these two soils, so far as we can now see, have an effect upon the chemical changes influential on the quality of the crop.

That color is to a considerable degree indicative of productiveness is shown also by the change which takes place in the subsoil between the time when it is freshly turned up and when brought into a condition favorable for crops. In the Atlantic Coast States, particularly, it is not uncommon to find subsoils deleterious to crops if too much of the material is turned up at any one time by the plow, and it is interesting to watch a skillful gardener improve a piece of raw land of such character. He adds a little manure and spades it in lightly, and still the soil is not in first-class condition for a crop. He lets this lie four or five weeks and respades and finds the color gradually and slowly changing. It may take three or four years to produce a fertile soil out of the raw piece of land or out of a subsoil in this way, and his experienced eye can tell from the color changes the rate of progress with which the change is taking place. The gardener knows that by his methods of soil fermentation and by the increased oxidation brought about by intelligent methods of handling certain changes have taken place in what was formerly the raw subsoil to fit the material for crop production. In this case it is not the lack of organic matter, for this can be supplied at once, but it is the form or the condition of the organic matter in the subsoil which indicates to him unfavorable conditions for plant growth, and these conditions he ameliorates or changes both by the addition of organic manures and by judicious cultivation.

The soil expert knows what can be accomplished by these artificial means, but he knows that no means are available to produce the Cuban tobacco of high aroma on the yellow soils of the Norfolk series or the Sumatra type of wrapper leaf of equally high quality on the red soils of the Orangeburg series. He also knows from experience that with the highest art of cultivation the black soils of the Portsmouth series will produce different crops—or the same crops of different quality—than will the black soils of the Houston series.

The red color of the soils of the Cecil series and the yellow color of the Chester soils are recognized by our field men to indicate differences in their relation to crop production and to cultural methods, and there is no question in their minds that the soils should be separated into different series.

In the glacial regions the black soils of the Marshall series and the yellow soils of the Miami series are another striking example of differences in crop adaptation indicated by color differences. The greater productiveness of the darker soils is not dependent upon the amount of organic matter, because two soils may have the same amount of organic matter and yet have entirely different crop values, but is due, as we think, to differences in the condition of the organic matter. This is probably determined by certain chemical changes, which may be the result of biological agencies, and which in any event are apparent in the color differences of the soil.

Instances of this kind could be multiplied, but it seems unnecessary. It is on account of these slight differences in structure and slight differences in color that we still have a number of soils among the types so far mapped in the United States that we have not been able to correlate into series. In the Coastal Plains there are five loams and five silt soils, for example, having approximately the same texture as other soils which have been placed in series, but differing so much in structure or in the shade of the color that they have never been classified. We can at present find no relationship between them and other soils, and this is borne out by the experience of farmers, who testify as to differences in soil management, crop adaptation, yield, or the quality of the product, which justifies us in excluding them from any of the established series.

Too much emphasis can not be laid upon the fact that we do not consider the color itself a factor in crop production, but only as indicative of soil conditions, of chemical powers or of the kind of decomposition which normally takes place under cultivation, affecting in one way or another either the yield or the quality of the crop produced.

SOIL PROVINCES OF THE UNITED STATES.

We thus have soil series comprising types alike in all respects except in texture and in such physical properties as texture determines. We then have the types in these series and a number of unclassified types, which are put for the time into a group of miscellaneous soils. The complete scheme of classification, so far as perfected by the Bureau of Soils, also provides for the grouping of these series and the associated miscellaneous types into thirteen great soil provinces, as shown in the map accompanying this bulletin. This broader grouping depends upon certain similarities in the soil, due in part to the character of the original material and, in part, to dominant agencies operating in the formation of the soils.

FACTORS GIVING RISE TO SOIL PROVINCES.

The principal factors which have been contributory to our soil provinces will be discussed under the following heads, the actual description of the provinces, their series and soil types being reserved for the second part of this bulletin. The main idea intended to be conveyed in this brief summary is the fact that the soil minerals found in the different soil provinces do not materially differ in character, but that the soil peculiarities characteristic of the different provinces are the results of the operation of the different agencies about to be discussed, as follows:

Climate.
- Humid.
- Arid and semiarid.

Heat metamorphism.

Ice, rushing glacial water, and wind attrition.

Lakes.

Oceans.
- Wave action.
- Simple repeated submergence.
- Same modified by shell fish débris.

Rivers.

Topography.

Volcanoes.

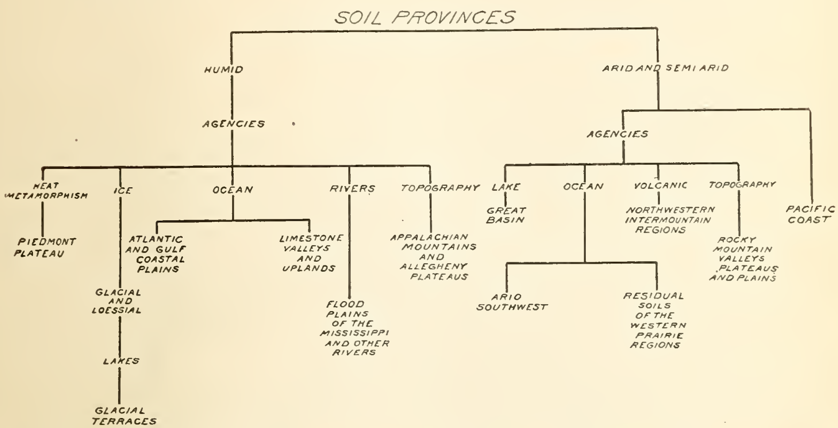


FIG. 3.—Soil provinces of the United States and the dominating factor in their formation.

CLIMATE.

Each of the agencies stated has had or has a profound effect upon the constitution or properties of the soil material, and each influences directly or indirectly crop adaptation and soil management. The arid and humid conditions marking broadly the western and eastern half of the United States have given rise to marked differences in soil features. Under western arid conditions there is little noticeable difference between the soil and subsoil in texture and but little difference in color. There is remarkably little true clay soil, such as encountered in the East, sands, loams, and silts predominating. Many soils of differing textures have adobe properties, which are unusual in the East. The soils and subsoils as a rule have neutral colors, generally gray or black, although many of the rocks give brilliantly colored disintegration products. The soils frequently contain quite noticeable amounts of soluble salts, which accumulate in places, resulting in alkali conditions. The soils generally contain less organic matter than the soils of the East, and a large proportion of this is in the stable form. The soils generally, and notably the subsoils, appear freer of toxic organic bodies than eastern soils and are almost universally capable of producing larger yields under irrigation. When irrigated, or even when dry-farmed, the texture is not so controlling a factor in the distribution of crops as in the soils of the East. Plants develop a much deeper root system than on soils of the East. With little difference in texture between soil and subsoil, with the infrequent rains, and the dry atmosphere and generally rapid surface evaporation, a more efficient surface dry mulch can be maintained, making it possible to produce good yields of crops with remarkably light rainfall, frequently without any at all during the growth of the crop.

HEAT METAMORPHISM.

This agency has given us the materials from which the soils of the Piedmont Plateau, which have generally a bright red or yellow subsoil, the former characteristic of the Cecil and the latter of the Chester soils. The material found in the Piedmont soils has contributed directly or with intermediate changes to most of the soils of the United States, but through the agencies of soil deposition, about to be discussed, the soils outside this province have altogether different properties. It must be remembered that our sandstone and shale are débris from these crystalline rocks worked over and sorted out by water and reconsolidated into rock, and that our limestone soils are the same materials contained as impurities in the limestone rock, and that all these common rocks contain most of the common minerals.

ICE, RUSHING GLACIAL WATERS, AND WIND ATTRITION.

These agencies, which in common grind up the crystalline rocks, sandstones, shales, and limestone, give rise to soils very different from the soils of the Piedmont Plateau, where the crystalline rocks have disintegrated in place, different from the soils of the limestone valleys, and different from the soils derived through degradation of sandstone and shale in place. The granitic material so ground up does not take on the bright-red color of the Cecil or the shade of yellow of the Chester soils. The ground-up limestone does not take on the brownish-red color of the soils of the limestone valleys. There are two main series of glacial soils—the yellow Miami soils of the rolling uplands and the black Marshal soils of the prairies. When limestone fragments evidence the incorporation of limestone material, and often when these larger fragments are absent, the fine earth contains sufficient lime carbonate to cause an effervescence with acid, which is not the case with the soil of the limestone valleys, which are characteristically low in lime content. Furthermore, the physical properties of these glacial soils, when the rock origin can be determined, is entirely different from the soils resulting from the disintegration of similar rocks in place without the glacial area. These physical differences and their connection with the causes that bring about the difference in color has not been determined, nor can it at present be determined or expressed in any specific way. It can, however, be detected by a trained observer, and even by the casual observer, that there is a difference, and this difference, whatever it may be, gives a different character to the soils, requires different methods of soil management, of fertilization, and of cropping. The difference in the material has impressed itself upon the topography, and erosion has given the region a character peculiar to itself.

LAKES.

Around the Great Lakes, and elsewhere throughout the glacial region, where this glacial material was reworked when lakes covered larger areas than at present, the material presents itself in still a different form, due to the intervention of water action. The lake terraces and old lake flats were formed, giving rise to soils adapted to special crops that find here peculiarly favorable soil conditions.

OCEANS.

More striking perhaps, because the soils are more direct in derivation and adjacent in position, is the comparison between the Piedmont Plateau soils and those of the Atlantic Coastal Plains. The soils of both provinces have been formed from the same material, but in the case of the Coastal Plain types the material has been washed down, submerged beneath the ocean, elevated, again submerged, and reelevated a number of times.

The material here has again changed its character. The same minerals are found in the soils, but the color, texture, and physical properties of the soil material is changed. The material, it is true, has been sorted out by running water and by wave action, but the clays of the Coastal Plain are different from the clays of the Piedmont Plateau; so are the loams; so are the silts and sands. The Orangeburg soils, it is true, are red, but it is a different color from the red of the Cecil soils. The Norfolk soils of the Coastal Plain have a yellow subsoil, but it is different from the yellow of the Chester soils of the Piedmont. The variegated colors of the Susquehanna, changing from brilliant red to yellow, blue, or black, have no prototype in the

Piedmont Plateau, although derived from the same material. While differing among themselves there are certain similar characteristics running through the soils of the Coastal Plain which result from their common origin and mode of formation, and which mark them as belonging to a different soil province than the soils of the Piedmont Plateau. In this region also peculiarities in the physical properties of the soil and consequently in the character of erosion result in a different form of land surface.

The Gulf Coastal Plain, derived and formed in the same way though locally modified by glacial material, has soils in common with the Atlantic Coastal Plain, although many new soils are encountered here, owing to the conditions of sedimentation, and it is possible that this region should be set off as a separate province. Where during the periods of submergence shellfish have abounded, we may have calcareous deposits in the form of marl, coral rock, and true limestone.

RIVERS.

Along the course of the large rivers we have a class of soils differing again in color and in physical properties from the material from which they were derived. The color and physical properties are changed with any extended river action, and yet all soils so formed have certain characteristic properties and peculiarities which group them in a separate soil province. Even within the Piedmont Plateau itself the soils derived from the upland, worked over, and deposited by river agencies are so changed as to constitute new types.

TOPOGRAPHY.

The influence of abrupt topographic changes, as in our mountain ranges and elevated plateaus, tends not so much to modify the character of the soil as does the action of the other agencies mentioned, but rather by reason of the slope and elevation it has the effect of adapting them to special crops and to make necessary different methods of soil management. The Porters clay of the Appalachian region would be the Cecil clay if on the Piedmont Plateau, but from its position, slope, and elevation it is essentially a different soil to the farmer, and is put in a different province because of this relationship with other soils of the Allegheny Plateau.

VOLCANOES.

There are also in the Northwestern States a considerable area of soils derived directly from true volcanic material, such as basalt, volcanic ash, and other forms of volcanic material.

UTILIZATION OF SOILS.

THE PROBLEM.

The art of soil management is so to manipulate and handle 4,000,000 pounds of raw material—the weight of soil 1 foot deep on an acre—at an average cost of $10 or $12 as to produce the greatest quantity of food and clothing and still leave the soil unimpaired for future generations. The highest art is usually ascribed to the individual who secures the greatest net returns in money or the best grade of product. The best chance of attaining the highest art is in the long run in the hands of the man who has a thorough understanding of the nature of the soil and how to handle it, of the crops adapted to it and their needs, and of the market demands; in other words, who can make the most of the proper utilization of the conditions and resources above mentioned.

THE CLIMATIC CONDITIONS.

The first condition determining the proper agricultural use to which any soil can be put is climate, which limits broadly the zone or area in which certain field crops can be grown, and which affects the yield and quality of the products to a very marked degree, even within the area of profitable cultivation. The climate of the continental United States varies greatly, probably much more than is generally realized. In the southwest we have the semitropical arid climate. In southern Florida we have the semitropical humid climate. Over the country as a whole we have from more than 60 to less than 10 inches of rainfall and a range in mean temperature of more than 70° F. to less than 40° F. The elevation of our arable lands varies from below sea level to over 6,000 feet above. We also have varying types of rainfall; the greatest precipitation may occur in the winter months or may come in the summer months. We have great differences in relative humidity and in sunshine. We have differences in the range of temperature, both seasonal and daily, and we have differences in the length of the growing season. Finally, we have differences due to slope, exposure, large bodies of water, and to other conditions too subtle for us to measure, which may determine the special fitness of a soil for a particular grade or quality of product. So complex are all these conditions and so indeterminate their individual or combined influence on the crop that no exact expression can be given for the climatology of any particular locality. In fact, with all our recent advance in meteorology, it is generally conceded that we still know very little about climatology as this term is used here.

The very simplest conditions, however, namely, the distribution of the mean annual precipitation and the mean annual temperature, will indicate the great variety of meteorological conditions which prevail in the continental United States.

The following table and diagram (fig. 4), made up from Weather Bureau maps and records, show the normal annual precipitation in the United States and the proportion of the area covered by each of ten grades of precipitation.

Normal annual precipitation in continental United States, showing percentage of area having normals within certain limits.

Area.	Rainfall.	Area.	Rainfall.
	Inches.		*Inches.*
9 per cent	0–10	16 per cent	40–50
30 per cent	10–20	10 per cent	50–60
13 per cent	20–30	1 per cent	Over 60
21 per cent	30–40		

From this table it will be seen that about 30 per cent of the area has a precipitation of 10–20 inches and 21 per cent has a precipitation of 30–40 inches.

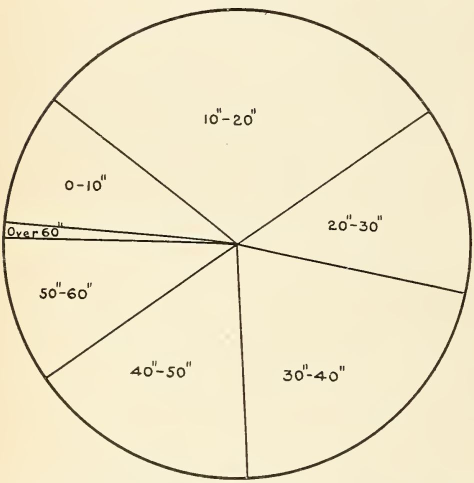


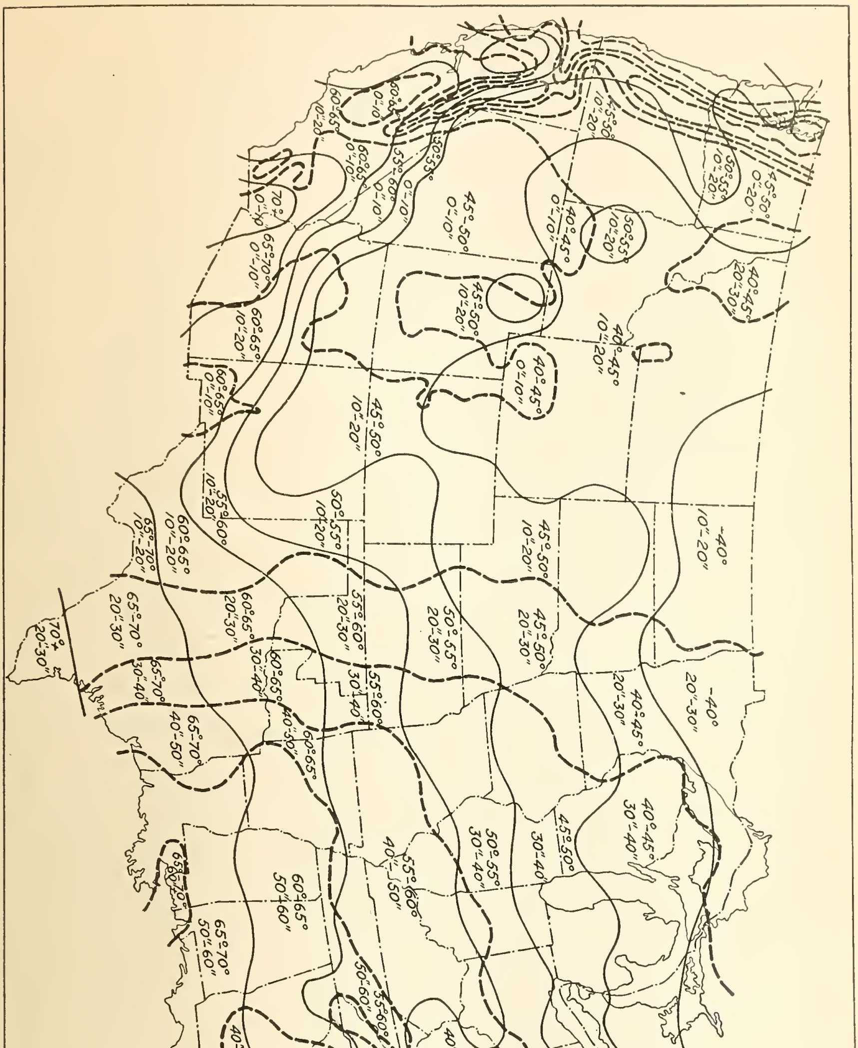
Fig. 4.—Proportionate areas of the United States according to certain limits of precipitation.

Figure 4 shows the proportion of the area covered by each grade of precipitation as compared with the whole area of the United States, represented by the circle, each grade being shown by segments of the circle.

The following table shows the areas having certain normal annual temperatures by steps of 5 degrees Fahrenheit.

Normal annual temperature in the United States, showing percentage of area having normals within certain limits.

Area.	Temperature.	Area.	Temperature.
	Degrees.		*Degrees.*
6 per cent	Below 40	14 per cent	55–60
18 per cent	40–45	13 per cent	60–65
24 per cent	45–50	9 per cent	65–70
14 per cent	50–55	2 per cent	Over 70



SKETCH MAP SHOWING AVERAGE ANNUAL TEMPERATURE AND PRECIPITATION IN THE UNITED STATES.

For example, 24 per cent of the area of the United States has a normal annual temperature of 45° to 50° F. and 13 per cent a normal between 60° and 65° F. Figure 5 shows these facts diagrammatically.

Combining the data in the two tables into a single diagram, in which neither the temperature nor the precipitation is drawn to scale, we get the relations shown in figure 6. From this figure it is seen that with a precipitation of 10 to 20 inches we have in some part of the country all grades of normal temperatures from below 40° to 70° F. and over. With a rainfall of 40 to 50 inches we also have all these variations of temperature. Or looking at the matter from the other side we have a rainfall of over 60 inches, only with a normal temperature of from 45° to 60° F. We have a rainfall of 50 to 60 inches in connection with all temperatures of 45° to over 70° F., and with a rainfall of 30 to 40 inches we have mean temperatures ranging from below 40° to 70° F., but not above. In other words, with these variations of normal annual precipitation, shown for intervals of 10 inches for each grade, and of normal annual temperature with intervals of 5° F., we have 46 combinations of these two simple factors alone, which may influence crop development and may influence the utilization of soils.

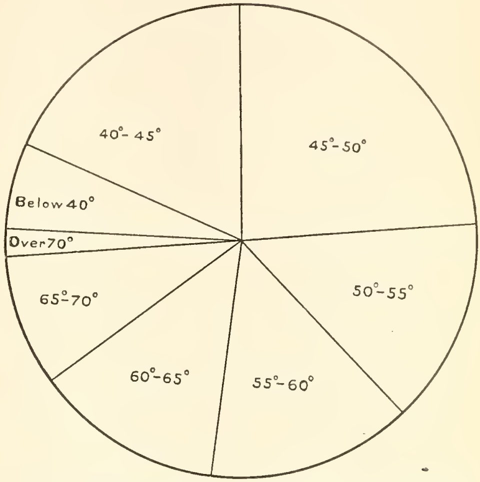


FIG. 5.—Proportionate areas of the United States according to certain limits of mean temperature.

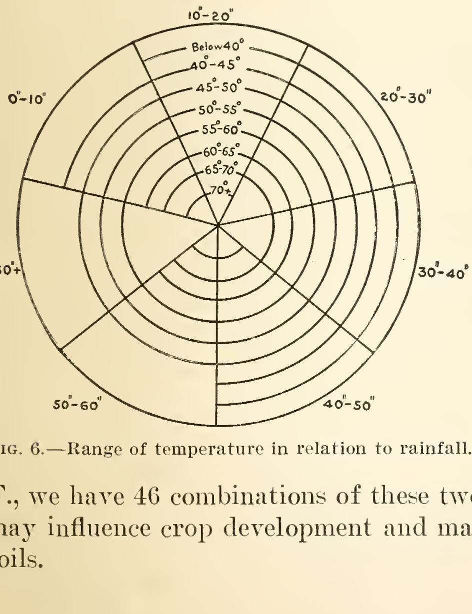


FIG. 6.—Range of temperature in relation to rainfall.

While it is not possible as yet to give an expression to meteorological data which will be a sufficient guide to crop characteristics, it is possible by careful observations of crops and native vegetation to form very accurate estimates of crop possibilities and to define areas in which certain crops having certain qualities can be produced. Such an area as the tobacco area of the Connecticut valley is a case in point; also areas producing sugar beets, sweet corn, and some varieties of fruits. There are special localities where grapes are known to do exceptionally well. The Albemarle pippin, which grows best on one particular soil, takes on its brightest color only when grown on this soil in sheltered coves between certain elevations in the Blue Ridge Mountains.

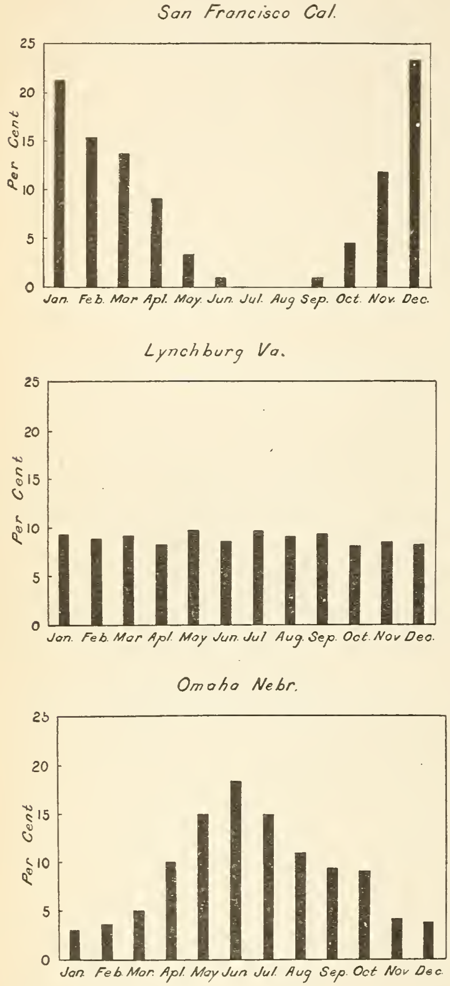


FIG. 7.—Three types of rainfall in the United States.

The differences in climate not only affect the plant directly, but have a great effect upon the soil and its chemical properties or composition—particularly in regard to the chemistry of its organic constituents—making the soil to this extent a different soil and thus affecting the plant.

The following diagram (fig. 7), taken from Weather Bureau records, shows three extreme types of rainfall—that at San Francisco, Cal., where the greatest amount falls in the winter and practically none in the summer months; at Lynchburg, Va., where the amount is quite uniformly distributed throughout the year; and at Omaha, Nebr., where the largest percentage comes in the summer.

THE SOIL RESOURCES OF THE UNITED STATES.

There have been recognized and described by the soil survey in continental United States 715 different types of soil, classified, so far as possible, into series, where the only observable fundamental difference which can not be changed by cultural methods is one of texture and the water-holding power incident thereto, and these again into great soil provinces, in which the materials differ by reason of the divergent forces that have resulted in their formation.

Many of these soil types extend over large areas and under different climatic conditions, and this must be considered in utilizing the soil in any particular line, so that the problem of soil utilization does not seem an easy one. Fortunately, however, we have many reliable guides, as, for instance, the character of the native vegetation, the growing crops, and the experience of farmers, which, together with the methods of study and investigation recently established, make the working out of the principles of utilization for any given soil type and locality far less difficult than it would at first seem.

ADAPTATION OF SOILS TO CROPS.

The principles governing the adaptation of soils to crops may be briefly stated.

The plant must have in the soil and in the atmosphere a congenial and sanitary environment.

The plant is fixed in position in a medium which has previously been occupied by a crop, and which has thrown off waste products.

The sanitation of the soil must provide for the absorption and change to harmless forms of such waste products.

Soils under different climatic conditions, with differences in elevation, slope, drainage, and from certain obscure chemical powers, apart from differences of texture, are able to provide more or less perfectly efficient sanitary conditions for certain crops.

That these differences of adaptation of soils to crops do exist is clearly indicated by the fact that natural plant associations differ for all types of soils which have been encountered, both as to kind of plants and relative numbers of the different species. The prevalence of certain trees or weeds frequently offers safe indications of soil conditions and of crop adaptations. Hilgard lays great stress upon the importance to be ascribed, especially upon virgin lands, to the character of the native vegetation. In our own work the character of the native vegetation frequently affords a very safe guide to the prevalence and amount of alkali salts contained in the soils of any particular locality. Some native plants are not found where the salt content exceeds 0.20 per cent. Other plants are characteristically found where the salt content is very much higher. These indications, however, differ in different places, and, as one would expect, for different types of alkali. It is a well-known fact that cultivated crops differ as regards the amount of alkali—and this varies with the character of alkali—which they can withstand. Alfalfa is exceedingly sensitive. Sorghum and sugar beets, on the other hand, are very resistant. In the development of the tobacco interests in the Miami Valley, Ohio, the sugar maple was taken as a safe indication of the soils on which the best grades of tobacco could be produced.

Perhaps nowhere is the use of character of the native vegetation as a guide to the utilization of soils more marked than in certain areas in Florida. With little or no observable difference in the character of the soils the hammock land, with its luxuriant growth of hardwood trees, is considered the strongest and most reliable land for the general crops of the locality. The high pine land, with its sparse growth of well-developed pine, is second in importance, being adapted, under intensive methods of cultivation, to the production of early truck and vegetables, though rather less valuable for citrus fruits than the hammock land. There are large areas of scrub growth consisting of dwarf and thick-leafed vegetation, frequently surrounded by high pine lands, with no apparent difference in the soil, but these two kinds of native vegetation never intermingle and the scrub land when cleared is not adapted to crops.

We have, on the Eastern Shore of Maryland, land known as the "white oak lands," poorly adapted to corn and even less suitable for other intertillage crops. The white oak is characteristic on this land, not because it grows better on this soil or because it is not found on other soils, but because of the fact that other varieties of oak are seldom found and the white oak is the dominant species. We have the case of the gradual disappearance of the chestnut trees in many areas in the Eastern States and the substitution of other native vegetation. We have very marked instances of the natural rotation of pine and hardwood growth, the soil always being better for agricultural crops following the hardwood than following the pine. Where the sassafras and sorrel come into the soils of the Coastal Plain as a dominant feature of the native vegetation, it is realized that the soil conditions have changed and that the soils are not so well adapted to the ordinary farm crops. Lastly, we have the very striking differences in the native vegetation on the black soils of the Marshall series and the light soils of the Miami series in the Middle West. The former were originally almost exclusively prairie and covered with a heavy growth of native grasses, while the latter carried distinctively a forest cover. There appears to be an incompatibility of association between trees and the grass, and we find characteristically the prairie sod on the one soil and the forest growth on the other, with little or no mingling of the species on the soils of the two series. After cultivation and the working out of the prairie sod trees apparently grow as well on one type of soil as on the other.

Besides pointing out the value of natural vegetation as an indication of the character of the land and showing the advantage which may be taken of the different periods of natural rotation, it is as well to say here that there are certain undesirable plant associations that should never be allowed in the proper utilization of soils. Weeds are almost always injurious to crops in the early stages of growth, as the excreta from the weeds are generally toxic to the plants. In the same way trees are generally injurious to plants in their immediate vicinity, and grass and trees on certain soils react on each other, resulting in the injury and even death of one or the other, while on other soils, and especially with certain trees, grass does very well.

It is seldom safe or desirable to follow a crop with the same crop without resting the soil for a full year, or better still, raising one or more crops of different kinds in the rotation. It is undesirable to use for peaches land from which a peach orchard has recently been removed. Corn, cotton, or tobacco reset after the death of the first plant, if the first plant made any sort of growth, seldom make good plants.

Exceptions may be found to the above statement of the undesirability of continuous use of the soils for one crop. On the Podunk fine sandy loam in the Connecticut Valley tobacco has been grown continuously on some of the fields for twenty-five or thirty years, and it is considered that the quality of the leaf is steadily improving. That the soil can and does adjust itself to the requirements of crops is seen in the case of native vegetation, while the delicacy of the adjustment at times may be seen by the difficulty of reseeding the buffalo grass after the western prairies have been broken up with the plow. The case of the English meadows is another instance of long-continued use of a soil for, in this case, a mixture of plants, with the resultant gradual changes in proportion, although the delicacy of the adjustment is again shown in the infinite care and long time required to establish a perfect sod.

With our annual crops we have the case of the continuous cultivation for many years of cotton, corn, and wheat in certain soils in certain sections, but it is becoming more and more evident that this is neither safe nor judicious, while on many soils in many sections of the country the results have been very disastrous, as the soils have been overloaded with excreta and toxic organic matter until the endurance or the efficiency of the soil has been completely broken down, and the soil, as we say, is worn out.

More striking than these field conditions is the liability of greenhouse soils to break down with the production of large crops in small volumes of soil. With some plants, as, for example, the chrysanthemum, but one crop can be taken, and the soil must then be renewed. No fertilizers or treatment will enable it to produce successfully a second crop immediately. With other crops and with some soils the endurance is longer, but eventually the soil must be renewed to produce the same crop, although fertilizers and manures are used in abundance.

TEXTURE AND STRUCTURE.

Turning now to conditions and properties which are apparent or can be measured, we have first of all the influence of texture. In what we call a soil series, where the material differs only in texture the lighter members of the sandy types, if not too coarse, are adapted to the early spring vegetables, the intermediate loam types are adapted better to wheat, corn, cotton, and general farm crops, under suitable climatic conditions, and the heavy clay types are better for grass and soiling crops for dairying and stock raising. This is general over the eastern half of the United States, but not specific, as there are many modifying influences. For instance, a rather fine sand in a low situation where a more moist condition than usual is maintained produces good yields of wheat. Also, after the intensive fertilization given truck or tobacco a good crop of wheat may be produced on land too light for profitable culture in this crop under general farm methods. It may therefore be given a place in rotation with special crops when it would not be advisable to grow it under less intensive culture given other crops. Also when clover runs out and has to be omitted from the rotation it is often inadvisable to grow wheat on a soil which would otherwise be considered suitable, because the yields can not be maintained without the intervening clover crop.

Corn may often be recommended for a soil not particularly adapted for this crop, because of its value in the rotation and as a necessary feed for farm stock. Such utilization of soils is only justified when other crops equally valuable for forage and grain and better adapted to the soil can not be found.

The structure of the soil as determining the compactness and affecting root penetration and æration, as well as drainage conditions, has much to do with crop adaptation. The crawfish lands of Tennessee are extreme types of soils which run together when wet into an almost impenetrable mass. The so-called mortar beds of Texas, as well as the soils with hardpan underlying, are all examples of undesirable soil conditions, and result in soils that have no general or peculiar adaptation to any of our valuable crops. These conditions can, however, often be relieved or entirely removed by cultural methods. The Susquehanna clay, between Washington and Baltimore, for example, in its natural field condition is very unproductive, but when this is worked up into a granular mass it is as productive as our limestone soils. This improvement can be brought about in the field after long and intelligent working with moderate applications of manure and lime.

Extreme plasticity, as in the black waxy soils of Texas, and the adobe property exhibited by many of the soils of California, affect the utilization of soils, mainly through the methods of management of the soil necessary for profitable crop production.

Drainage conditions, as such, have much to do with soil utilization. Certain crops like rice will produce well only when the soil is submerged with water for considerable periods of their growth, and structure has much to do with ease of flooding and consequently with cost of production. Others, like cranberries and peppermint, will do well in bogs; celery, onions, cabbage, and potatoes do well on muck if properly drained; pineapples grow on the loose beach sand of Florida, which is excessively drained.

It is not unusual to find the character and depth of the subsoil influencing the drainage conditions of a field and affecting the utilization of the soil. This is particularly marked in the case of tobacco in southern Virginia and in North Carolina, where a few inches difference in the depth of the clay subsoil below the surface means the difference between the utilization of the soil for bright leaf cigarette tobacco or the heavy types of export or manufacturing tobacco. Such variations also affect very materially the yield of wheat and other crops, and thus influence the proper utilization of the soil.

Elevation and exposure are important factors in the utilization of soil. Examples of this are seen in the fine quality of grapes on the terraces and slopes in the lake region of New York, Pennsylvania, and Ohio; in the protection from frost and the consequent early maturity of truck crops on the peninsulas of the Atlantic Coast States; in the protection from frost on the foothills and mountain sides. Citrus fruits can not safely be grown upon soils which would otherwise be adapted to them in the San Joaquin Valley, California, but are grown very successfully on the foothills bordering the valley. Peaches are successfully grown on the Maryland-Delaware peninsula and in the mountains of western Maryland, but not with safety on the intervening Piedmont Plateau (although the soils are otherwise well adapted to the fruit), on account of frosts which are liable to occur when the fruit buds are so far advanced as to be easily killed.

A very striking illustration of the effects of elevation and exposure on the possibility of soil utilization is seen in the case of the apple industry of the Appalachian fruit belt. In New York winter apples are commonly grown at an elevation of from 100 to 600 feet above tide. In the Virginia mountains the suitable elevation is not less than 900 or 1,000 feet or more than 2,000 feet, or, say, at an average elevation of 1,500 feet. In North Carolina the elevation for successful and safe crops is a thousand feet higher than in Virginia. Farther south in Alabama the safe elevations are lower than in North Carolina. The finest Albemarle pippin apples are grown on the Porters black loam between 1,000 and 2,000 feet elevation, but only in sheltered coves—not on the exposed sides and tops of the mountains, although the soil may otherwise be well adapted to the fruit. In North Carolina in the lower elevations of the fruit zone the fruit does best in the coves on the north side of the mountains, while at higher elevations it does as well or better in coves with southern exposures.

The color of soils is very often—probably much more often than we realize—an indication of the adaptation of the soil to crops and an index to the proper utilization of the soil. Examples of this are very numerous, and the soil-survey field book of the Bureau of Soils contains a great many miscellaneous soils that can not be correlated with the great series, very often because of differences in crop values which are associated in some way with slight differences in color of soil or subsoil. We never correlate a red soil with a yellow soil, because we know the crop will be different—if not in yield, at least in quality—and, while the crops of the locality may be valued by the quantity grown, we never know when new crops will be introduced in which quality is an important factor. There is, furthermore, a growing tendency to recognize quality in both wheat and corn for different commercial purposes. Quality is a controlling factor in tobacco production and is very important in fruit production.

The red soils of the Orangeburg series of the Coastal Plains are stronger and more lasting under hard usage than the adjacent yellow soils of the Norfolk series. The former will produce more cotton and will stand more continuous culture with the same good treatment. In Alabama and Texas they will produce a cigar-filler leaf of fine aroma, while the Norfolk soils will produce a finer grade of Sumatra wrapper leaf without aroma. What gives the red soil more lasting fertility we do not know. We think it is not directly due to the red iron compounds in the one soil and the yellow iron compounds in the other, but to the conditions or physical forces or chemical properties in the soil, which are able to keep the iron compounds in different conditions of hydration and oxidation in the one case than in the other, which forces appear to play an important part also in the maintenance of proper sanitary conditions in the soils.

The yellow Norfolk soils and black Portsmouth soils are very different in their crop production. The former are adapted to early potatoes, peas, radishes, lettuce, and the lighter spring vegetables; the latter to cabbages and the heavier truck crops. Organic matter added to the Norfolk soils darkens them very little, but when added to the Portsmouth soils makes them still blacker, indicating a difference in the process of decay or in the final stable form of organic matter in the two soils, and affecting in some way their adaptation to crops. Whether this difference in the chemical changes in these soils is associated in any way with the forces which determine the form of the iron compounds in the Norfolk and Orangeburg soils referred to is unknown.

Instances of this kind, where slight differences in shade in the red, yellow, or black soils are associated with differences in yield or quality of crop, at least in certain seasons and under certain conditions of temperature and rainfall, could be multiplied indefinitely. It was a certain peculiar and unusual shade of brown in thin layers in the subsoils of certain soils in Florida which put us on the track of the probable cause of the dieback disease of the orange, which appears to be due to the presence in the soil of a toxic organic compound, which, however, has not yet been isolated or identified.

The peculiar adaptation of soils to special crops has long been recognized. Nowhere is this more strikingly shown than in greenhouse culture, which, where manures and fertilizers are so abundantly and intelligently used, is the last place one would expect to find it. The hothouse lettuce of Boston has long been esteemed the finest product of the kind received in the New York markets. The soil used in the houses is peculiar to the locality. The soils used in the greenhouses around Washington and Alexandria will not produce this fine quality of lettuce, but can and do produce fine violets, with a rich aroma, and these have the highest reputation in the New York and Philadelphia markets. In general, the roses grown in the greenhouses around New York are of the highest rank and are so held in the Boston market, but certain varieties like the American Beauty can not be produced there in the perfection that is attained in the greenhouses of Philadelphia and Washington. So it goes with any greenhouse crop and with each variety of the crop, the soils of certain localities have peculiar advantages, small oftentimes, but with so highly specialized an industry, where quality is so important, enough to give a deserved reputation to the locality and to bring better prices to the grower.

That these differences are real and are associated in large part with the soil and its peculiar adaptation to crops can not be doubted, nor can these peculiarities be entirely overcome by the most skillful greenhouse man. So intense is the cultivation of some of these crops that the soil would appear to be a minor and almost unimportant factor. In the cultivation of the modern varieties of chrysanthemums so much manure is used that the soil seems almost a negligible factor. In addition, the plants are watered with soluble fertilizers up to the very limit of their safe endurance of saline solutions, but after the crop is over the soil must be thrown out, as it is unable to support a second continuous crop of equal quality with the first. Rose soils retain their power of producing fine quality much longer, but with the best care they too have to be thrown away eventually and fresh soils used if the quality is to be maintained. The proper utilization of soils in greenhouse culture and the selection of crops and varieties to be grown is coming to be recognized by the leaders of the industry as of the highest importance.

There is a great field for investigation by soil experts of the cause of this adaptation in these highly specialized industries—a field offering problems which with our modern methods and knowledge it seems possible to solve, and it is perhaps from a study of the conditions surrounding these intensively cultivated forcing crops that the most important light will be thrown upon the general field conditions.

Reference has already been made to the special adaptation of certain soils to certain varieties of tobacco, fruit, and truck crops. It is coming to be realized now that in plant breeding consideration must be given to the character of the soil on which the strains have been produced, as well as to the character of the soil upon which it is proposed to use the selected seed for crop production. Cotton which has been carefully selected until it produces large crops on rich bottom lands will not do so well on sandy uplands. Breeding strains for each of the important types of soils must be by selecting from parent plants which will produce seed adapted to that particular type and its conditions. So far as we now know, this means that the seed should come from soils of the same texture and physical condition. We know this to be true of varieties of wheat and corn, although no general laws have been worked out to explain the wide variations observed in the records of our experiment stations and in the experience of farmers. Breeders of wheat and other crops recognize that some new varieties will be adapted to a wide range of soils and that other new varieties originated on the same soil will prove useful on some soils and will not succeed on others. Before distributing newly bred varieties it is necessary that they be tested on each soil type to which they are to be sent.

SOIL UTILIZATION WORK.

The work of the soil utilization parties of the bureau has been to see, so far as possible, that the soils of the several areas in which they were stationed shall be utilized to the best possible advantage consistent with the local conditions and market facilities and demands.

We should not need to rest the soil any more than we need to rest the atmosphere or the sun. But we do not want to overload or diminish the natural powers of the soil by injudicious methods of cultivation or cropping any more than we want the health-giving powers of the sun and atmosphere obscured by the fumes and smoke of our factories. Whatever may have seemed wise or necessary in the early settlement of the country, when but one or two crops could be grown and marketed, it is no longer necessary, with our vast transportation facilities and ever-growing markets, to overload or abuse the soil by making it produce crops to which it is poorly adapted or in such amounts and at such short intervals that it can not properly digest and take care of the excreta and waste products of the crop before another crop of the same kind is forced upon it.

Furthermore, it is quite probable that some of the soils which we count as unproductive and unsuited to our staple crops, or where the expense of putting them in condition for good yields would not at this time be justified, may be found peculiarly adapted to new crops for food, drugs, or fiber, or plants might be adapted to them by introduction and breeding. This has been the experience in many notable cases; for example, the utilization of the light sands of the Coastal Plains for truck crops, which only twenty-five or thirty years ago were considered, and which were indeed, under the conditions which had prevailed, quite worthless for agricultural crops. Also the utilization of the otherwise valueless coast prairie lands of Louisiana and Texas for rice culture, when a particular variety of rice able to stand the peculiar climatic conditions was found by one of our explorers in Japan. Many other instances could be given to show that much has been done in the profitable utilization of peculiar soil conditions, and it seems quite certain that much more will be done in the future along the same lines.

Much has been done in our laboratory investigations to throw more light upon the complex problem of the fertility and infertility of the soil, and great fields for new lines of work are opening up, based on what has been accomplished. Investigations in these fields will, we think, throw light upon the still more obscure problem of the forces concerned in the adaptation of crops to soil.

The work on the nature of the soil and the conditions affecting fertility has done much to clear up many practical problems and make more certain the proper methods of soil utilization and management. With this knowledge should go extensive knowledge of the soil in different parts of the United States, best gained through active work in the soil survey. With this must go a careful study of the climatic conditions and of the soil in the field as to the texture, color, drainage conditions, depth, and character of subsoil. The elevation and exposure must be considered, and then a very thorough study should be made of the character of the native vegetation, including trees, shrubs, and weeds, and their relative proportions and kind of development. Lastly, the vast experience of farmers must be consulted and the causes of their successes and failures must be studied.

There are, as will be seen by a careful study of the soil descriptions in the latter part of this bulletin, large areas of soils in the United States not now profitably cultivated to crops because they are unsuited to any of our staple crops. Somewhere in the world similar soils under similar conditions may be found adapted to special industries, and our agricultural explorers are finding and sending in plants and seeds which will enable us to take up some of the present waste lands. Much is also being accomplished through the development of irrigation systems, as well as through the reclamation of swamps and overflowed lands adapted after reclamation to special crops of high value, for example, truck crops, peppermint, celery, onions, and the like. We have, however, an apparently even more difficult problem in the utilization of some of our extremely sandy soils or barrens, where the sand is so loose and incoherent, so deep and dry, that none of our present crops are adapted to them. We also have large areas of gravel soils and stony soils that are of little use, although with the same amount of gravel and stones in other soils we can adapt them to very profitable purposes. We also have the extreme types of plastic clays, like the Susquehanna clay, covering large areas, very poorly adapted to any of our common crops, poorly adapted to fruit or forest growth, and which are so costly to improve that they are at present practically useless for profitable agriculture. It would seem that some kind of crop or some industry could be devised for the profitable utilization of these at present useless lands if the problem were conscientiously studied. We also have the utilization of vast areas of cut-over pine lands, and our people have to decide whether these can most profitably go back into forests, or, if they are taken up for agricultural holdings, what crops and what methods of cultivation can be adapted to them? Some of these lands it is known are strong agricultural soils, while others are known to offer such difficulties to the production of economic crops as to make the problem of their adaptation extremely difficult. Taken all in all, the problem of what we had best do with the great soil resources of the country, which becomes apparent upon a careful study of the soil series and miscellaneous types, is one which is well worthy of consideration and of intelligent and systematic investigation.

Some of these series are of small extent and are therefore relatively unimportant from a national standpoint, however important they may be to the States, and particularly to the individuals occupying them as farms. Some of the soil series so far mapped are larger in the aggregate than some of our States and larger than some of the independent countries of the world. The soil experts of the soil survey, making explorations and studies of these soils extending over different parts of the United States, under different climatic conditions and cultural and crop methods, and spending months and years in the study of similar types and series of soils, acquire an expert knowledge of the soils and the possibilities of improving them and our crop conditions which makes their judgment sought for by practical men who desire information as to the chances of success in the introduction of new industries, as to the improvement of existing conditions, and as to the varieties of fruit, truck or field crops that are adapted to certain soil types.

AGRICULTURAL RANK OF SOILS.

The soil type—the unit of soil mapping—may vary greatly throughout its extent in agricultural value, depending upon the proper handling of the soils, the advantage taken of opportunities for special crops, the proximity of markets, and the condition of transportation facilities. These are all factors that are changing from day to day, and the Bureau has never attempted to classify the soils according to their current rank as factors in our agricultural output, but rather to weight them on the basis of their potentiality, no matter whether they were being used to their full capacity, were lying idle, or were still in their virgin state.

Nevertheless, after nine years' work of the soil survey, it would seem that some new facts in regard to the relative importance of the several classes[a] of soils may be brought out by an arrangement of the soils on the basis of their present usefulness, and such a compilation, limited of course to the actual area covered by the soil survey, is summarized in the following table. The table gives the classes of soils, the number of types of soil in each class, the acreage of each class according to agricultural rank, and the total acreage of each class and each rank so far surveyed.

Soils of the United States grouped by classes and present agricultural rank.

Class of soil.	Number of types.	Relative agricultural rank.			Nonagricultural.	Total.
		First rank.	Second rank.	Third rank.		
		Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Stony loams and clays	45	998,262	710,235	5,000,050	1,664	6,710,211
Shale and slate loams	9		100,032	690,126	47,040	837,198
Gravelly loams	62	496,582	315,808	1,650,013	2,752	2,465,155
Sands	48	3,110,178	561,411	2,165,884		5,837,473
Fine sands	31	1,840,704	866,770	447,566		3,155,040
Sandy loams	74	3,445,691	4,958,165	1,805,421		10,209,277
Fine sandy loams	90	6,698,302	4,041,105	736,956		11,476,363
Loams	122	6,627,975	2,869,422	1,753,420		11,250,817
Silt loams	80	7,353,820	7,307,197	3,811,168		18,472,185
Clay loams	68	4,419.385	874,507	629,952		5,923,844
Clays	76	6,310,148	1,433,353	2,577,165		10,320,666
Unclassified	10	733,203	2,472,215	611,540	3,352,927	7,169,885
Total	715	42,034,250	26,510,220	21,879,261	3,404,383	93,828,114

[a] The "stony loams," "loams," "silt loams," "clays," etc., each form a class.

The foregoing table shows that the survey has encountered 164 types, amounting in the aggregate to 42,044,241 acres, which may be classed as of the first agricultural rank, 271 types with a total of 26,510,308 acres, of the second rank, and 271 types, with an extent of 21,869,182 acres, which may be considered at present of the third rank. In this grouping it must be borne in mind that the type is considered as a whole, and that an extensive soil, though highly developed in some particular area or areas, would still be classed with soils of lower rank if the greatest proportion of its area was indifferently utilized or used not at all. To take a concrete case, the Dekalb stony loam (area 749,496 acres), is classed with soils of the third agricultural rank, notwithstanding that it is used, in the mountains of Maryland, for instance, in the production of peaches, and is eminently adapted to this crop. The acreage at present in peach orchards is relatively very small, and the great part of the type still undeveloped determines its position in the third rank.

This example brings out clearly some of the problems awaiting solution by the Department. As has been pointed out, soils are not fixed by inherent qualities in the ranks to which their present utilization assigns them. Economic conditions are changing constantly, and these may make of great value soil areas that heretofore had scarcely been considered worth cultivation. The introduction of bright yellow tobacco in North Carolina, for instance, increased the price of the sandy lands tenfold. Some of the sandy types, which thirty or forty years ago would have been classed as of low rank, have by special adaptation to truck growing been changed during the last generation to a position of the highest rank. Similarly, by reason of special adaptation, some of the stony loams and clays have passed from the lower to the higher ranks. Some of this progress will come inevitably as the result of increasing rural settlement and the growth of urban population and markets; but one of the most promising fields for work that the Department has to-day is the field of research to discover special crop adaptations for the soils at present ranking as inferior factors in our agricultural economy, and thus to raise these soils to positions of greater utility. The most potent agencies working to this end will always be the selection of new crops and the aiding and fostering of new industries, though of only less importance is the question of soil improvement. The problem resolves itself into two broad divisions—the extension of established industries on soils of known high value for certain crops, and—a more difficult matter—the utilization of soils of unknown adaptations or perhaps of inherent qualities adverse to profitable cultivation.

FERTILIZERS AND MANURES.

The reason for the beneficial effect of fertilizers has long been held to be due to the supplying of mineral plant food to the soil in a more soluble or available form than is found in soils of low productive capacity. There are three great facts which have never been satisfactorily explained under this hypothesis: (*a*) Stable manure as a rule has a much higher fertilizer value than would be indicated by the amount of mineral plant food elements it contains. (*b*) Plants contain usually as much, or more, of silica, iron, aluminum, magnesium, and sodium as of nitrogen, potash, phosphoric acid, or lime, and the former group are as necessary to plant life and are quite as insoluble in their soil compounds as the latter; they are rarely used successfully as fertilizers, and they are not considered commercially as being in the class of plant foods. (*c*) Certain nonplant food substances, such as copper sulphate, ferrous sulphate, common salt, and some three or four hundred substances which have been tried from time to time do give occasionally very beneficial results. However, it is not always possible to explain any fact by hypothesis, however broad we make it, and as we know that nitrogen, potash, and phosphoric acid are essential elements of plants, and as we often get bigger yields after applying substances containing them to the soil, we have come to look upon the question as proved that they act solely or principally through feeding the plant.

Another fact which we have known for a long time and which we have not been able satisfactorily to explain is that dwarfed plants or plants on infertile soils often contain a larger percentage of ash than better plants grown on more productive soils. This would indicate that on such poor soils they are able to take up more potash, phosphoric acid, and lime than they are able to elaborate into good plant tissue.

The most advanced scientific work now shows that fertilizers have another and an important function in keeping the soil sweet and sanitary for the plants.

The natural supply of mineral plant food comes directly from the solution of the mineral particles of the soil. The solubility of these minerals gives a very dilute solution, but adequate in amount and rapidity of solution for the need of field crops. Furthermore, the soil has a great absorbent power, and soluble fertilizer minerals applied to the soil do not long remain in the free or capillary water in which plants are supposed to feed. That is, when a soluble phosphate salt is added to a soil in the usual amount, or even in much greater amount than is ordinarily applied, it can not again be obtained by simply washing the soil, as it is withdrawn from the solution and firmly held by the surface of the solid grains, and the soil moisture is not sensibly enriched by the application.

It has been shown that another cause of the low yields, in cases where the physical conditions of the soil are satisfactory, is the presence in the soil of toxic organic substances resulting in part from crops which have previously occupied the land, and very frequently through neglect of proper methods of tillage. A number of these toxic compounds have now been separated from the soil, identified, and their properties studied. These are rather instable compounds under certain soil conditions. That is, they can be rather easily oxidized or broken down into other bodies usually much less toxic or even beneficial, and often this oxidization or decomposition takes place more easily if readily decomposable organic matter like stable manure be placed in contact with them.

The infertility due to one of these toxic compounds of a soil is transmitted to an extract of the soil (water which has saturated the soil), and if seedling plants be grown in such an infertile extract the growth can be markedly improved in a number of ways: (*a*) By adding certain fertilizer salts; (*b*) by easily oxidizable organic matter like pyrogallol; (*c*) by absorbing substances like carbon black, absorbent cotton, or shredded filter paper; (*d*) by simple boiling, and (*e*) by diluting the soil extract with pure distilled water. The effect of increasing the vegetative growth shared in common by these agents can not be ascribed to the power of actually feeding the plant, for this power is possessed by only one of them.

The first and immediate effects of fertilizers is sometimes deleterious. Even if nitrate of soda be added to a soil which is known to respond to this fertilizer and an extract be made of the soil immediately after adding the fertilizer this extract may not be as beneficial as the extract of the unfertilized soil, while if the nitrate had been allowed to act on the soil for several days before the extract had been taken it would have been much improved.

The same thing has been observed with soluble phosphates, that is, that it takes an appreciable time for the beneficial results to appear and the first effect is often deleterious. This is even more pronounced in the case of green manure, which must have a certain time to act on the soil before it it safe for plants, although this is usually only a matter of a few days. When nitrates are added to infertile extracts and plants grown therein they often disappear entirely from the solution before their full beneficial effect is felt, as shown by the increased growth of the second crop of plants in the same solution from which the nitrates had been removed by the first crop.

Fertilizers destroy or change known toxic bodies, sometimes by combining with them to make salts which are nontoxic or beneficial and sometimes by actually increasing the rate at which the toxic organic bodies are oxidized, so that the most delicate chemical tests fail to show a trace of the organic substance that was present before the fertilizer was added. Very often plants themselves destroy the toxic material, and plants and fertilizers together often act much quicker and more effectively than either alone.

There is evidence, therefore, that the fertilizers do something to the soil to put it into better condition for crops. In disappearing the fertilizers have performed some function, have acted on some constituent of the soil that had heretofore retarded the growth of plants, and, by its removal, oxidation, or other change, have rendered the soil a better medium for the growth of the plant.

The results of fertilizer plot tests, along which lines a vast amount of work has been done, and the experience of farmers seem to indicate that in a majority of cases nitrates increase vegetative growth of plants; phosphates tend rather to check this vegetative growth or to produce relatively more seed, while potash appears to promote starch-forming activities (develop tubers in potatoes) and to improve the quality of fruits (for example, apples). Combinations of these elements often seem to show in their effect the results which would be expected from each alone, that is to say, a mixture of nitrogen and phosphorus may increase the vegetative growth and also increase the amount of grain produced on the wheat plant. By adjusting the proportion of these elements it has doubtless been possible in many cases to modify the crop within limits as desired. So, in the same way, with potatoes, a moderate supply of nitrogen, either in the form of nitrate of soda or of organic matter, in conjunction with potash, often produces an increased growth of vine necessary for an increased development of tuber.

Another fact which must be borne in mind in any fundamental study of fertilizer effects is that these effects are greatly influenced by weather conditions. It is a common experience that a brand of fertilizer or a single fertilizer constituent which has a decidedly beneficial effect this year may have little or no effect on the same soil and the same crop another year when the weather conditions are markedly different. It is this variation which makes fertilizer practice so uncertain. It is inexplicable from the plant-food idea. But if we view the soil as a receptacle for plant excreta and organic remains which in certain forms may be harmful to succeeding crops, and that this organic débris must, in order to render the soil safe for plants, decay, through oxidation or otherwise, to those products which we recognize, broadly, as humus bodies, then we may readily understand that the temperature, humidity (of both air and soil), and even sunshine and wind, may modify the process through which this decay goes on to such an extent as to change the intermediate bodies which may be formed. In the decay of the organic matter through fermentation or otherwise, not one but many intermediate bodies are formed, some of which may be beneficial and others may be more or less deleterious to crops and each having different characteristic properties and reactions with mineral salts. In other words, if we look upon the cultivation of the soil as a method to promote fermentation for the purpose of facilitating certain necessary organic changes and of rendering the soil suitable and sanitary for a subsequent crop, then we may expect an influence of climate on fertilizer effects, as we would have different intermediate decomposition products formed in the breaking down of the organic matter under different moisture and temperature conditions.

We have learned, furthermore, from the experience of farmers and from the more exact methods of plat and pot culture, that different combinations of the different plant-food constituents have different effects upon the crop. For example, the different salts of potassium, the different forms of nitrogen in mineral salts and in organic material, and the different forms of phosphorus have different effects on different soils, with different crops, and in different seasons. It is easy to show that it is the substance rather than the element, for the same plant-food element may be in compounds which are more or less beneficial or in other compounds which produce very unfavorable conditions in the soil, rendering them more toxic for plant growth.

Such in a broad way is our present state of knowledge in regard to the principles of fertilizer effects on soil fertility.

The Bureau of Soils has made a thorough comparative investigation of the fertilizer and manurial requirements of several hundred samples of soils from various parts of the United States, under as nearly as possible the same climatic conditions. These investigations show that fertilizers are relatively more effective on light than on heavy soils; also that they give, as would be expected, the greatest relative effect on poor soils rather than on rich soils, when both are put in good physical condition.

The results with commercial fertilizers, or rather with the mineral salts ordinarily found in commercial fertilizers, show in about 29 per cent of the cases that the elements are nearly interchangeable—that is, that nearly equal effects are obtained with common fertilizer salts containing potassium or nitrogen or phosphorus. About 11 per cent of the cases show that when two or more elements are used together the resultant increase in the crop is greater than the sum of the increase obtained by each of the elements used separately on other samples of the soil. Lastly, it is shown that in about 60 per cent of the cases the sum of the increase in growth due to each fertilizer constituent when used alone is greater than the increase obtained from a mixture of the fertilizer constituents applied to a separate sample of the soil, although the mixture gives a larger absolute increase than any one of the ingredients composing it when used alone.

Comparing, now, the relative efficiency of mineral fertilizers and organic manures, it is found that the number of cases where the greatest increase is obtained from the organic manures is far in excess of the cases where the mineral fertilizers have given the largest increase in plant growth. The actual results of this work showing the number of cases where organic manure or complete mineral fertilizers have given the greatest increase in yield are as follows:

	Per cent.
Manure	38
Cowpeas and lime	38
Complete mineral fertilizer and lime	20
Complete mineral fertilizer alone	4
Total	100

It would seem from this that for the greater number of soils the most efficient fertilizers of the future will be of organic rather than mineral origin, provided that when such a substance is found it can be obtained in sufficient quantity and at a sufficiently low cost and be at the same time less bulky to ship than stable manure.

There is a general feeling, although this does not seem to be borne out in practice, that both nitrate of soda and potash are more efficient in moderately cool climates and phosphates and organic nitrogen in warmer climates. The Bureau's comparative study under similar climatic conditions indicates that on the soils of the North Central States manure is about three times as efficient as mineral fertilizers.

In the soils of the Atlantic and Gulf States manure and green manure are about equally as effective as mineral fertilizers. It must not be forgotten that on certain soils, either under field conditions or in pots, manure appears to be deleterious and on some soils mineral fertilizers likewise appear to be deleterious, although the cases where either of these extreme results occur are very rare.

It has been shown by the investigations of the Bureau and also by others that the beneficial effect of stable manure is due principally to the organic constituents of the manure rather than to the mineral salts which it contains. We know, too, that the same food passing through a man, horse, cow, pig, or poultry gives, with the same mineral constituents, manures of very different properties and values, because of the difference in the character of the organic constituents resulting from the differences in the digestive processes and metabolic processes in the animals through which the food has passed.

In the case of horse manure we also know that it is advisable, and for some soils, as well as for some plants, necessary, to give the manure a preliminary fermentation before it is applied to the soil. In other words, on some soils we can safely use fresh manure and even have it contain a great deal of coarse litter, while on other soils we can safely use only well-fermented manure in which even the litter originally present has lost its form and has become well broken down. Straw as such is often deleterious when applied directly to the soil and turned under, but straw mixed with manure and partly fermented in the manure pile is beneficial to most soils, indicating a difference in the way decomposition proceeds, whether this starts directly in the soil or in the manure pile.

Of the organic matters used directly or indirectly as manure, the most effective are those containing a large proportion of nitrogenous bodies. The leguminous plants are the most effective as green manure and the manure from a grain-fed horse is more effective than from a horse fed principally hay or on pasture. The protein bodies are as a rule very complex and break down through oxidation, fermentation, and the action of enzymes or bacteria into bodies many of which are now known to be beneficial or detrimental to plants. The same original substance may break down into beneficial or detrimental substances, according to the agencies acting on it and the conditions under which they act. Fresh pea vines and pea-vine hay may, and usually do, give very different results when applied to any particular soil. Ground wheat seed and germinating wheat seed have very different effects upon the soil. So it is evidently not the nitrogen, but the compound, which determines the action on the soil.

It is generally believed that the beneficial effect of nitrogenous fertilizers is due to nitrification, through bacterial action, with the ultimate formation of nitrates, and this is undoubtedly important, not so much because of the nitrates formed, but because decomposition proceeding in that way is generally more beneficial than if it proceeds in other ways when other less beneficial intermediate products may be formed.

These nitrogenous bodies have a direct effect on soil conditions, making the soil either better or worse for plant growth. Some of the toxic bodies which have been separated from the infertile soils in our laboratories are nitrogenous bodies.

Coming now to a consideration of the commercial fertilizers, which are being used by our farmers to the extent of probably $80,000,000 or $100,000,000 annually, it is apparent that the nature of the substance containing the plant-food element is quite as important in judging of the efficiency of a fertilizer for any particular soil or crop as is the actual percentage of the element present.

The substances commonly used as carriers of phosporus in commercial fertilizers are the southern phosphate rock, ground bone, bone meal, boneblack, acid phosphate, reverted phosphate, floats, Thomas slag, and redondo phosphates.

The substances commonly used as carriers of nitrogen are nitrate of soda, sulphate of ammonia, cotton-seed meal, dried blood, tankage, fish scrap, guano, and castor pomace. Other nitrogenous substances, like horn, hair, feathers, and wool waste, are prohibited by the laws of many States from being incorporated into commercial fertilizers, as they are not considered good substances for fertilizer use, although they are highly nitrogenous.[a]

The substances commonly used as carriers of potassium are kainit, muriate of potash, sulphate of potash, and carbonate of potash. There are other potash salts, as, for example, iodide of potash and chlorate of potash, which are harmful and could not be used in fertilizers even if they could be obtained cheaply enough.

It is the experience of farmers and of investigators generally that these different carriers of phosphorus, of nitrogen, and of potash act differently on different soils and in different seasons and with different crops—that is, that raw rock phosphate, ground bones, boneblack, acid phosphate, floats, and slag are different substances which may act differently on different soils with different crops and with different seasons. Likewise that nitrate of soda, sulphate of ammonia, cotton-seed meal, dried blood, fish scrap, and guano are different substances in an agricultural as well as in a commercial sense, and this in addition to their differences in nitrogen content.

Most tobacco growers and many truck and fruit growers recognize a difference in the agricultural value of kainit, muriate, sulphate, and carbonate of potash as influencing the quality if not the yield of their crops. It is true that no definite law has ever been worked out even for a particular field, but this is probably due in large measure to a lack of knowledge of how these substances act and the influences which control their action on the soil.

It seems entirely probable that in the future we will require to know in buying commercial fertilizers not only the percentage composition of plant-food constituents, but the nature of the substances containing them. This would presuppose that the farmer knew whether nitrate of soda, cotton-seed meal, or dried blood would give the better results on his soil and for the crop he proposes to grow—a fact which it is not difficult to imagine he could determine for himself within limits with the wire-pot method devised and described by the Bureau of Soils.

---

[a] The Kansas law requires a guaranty from the manufacturer or seller desiring to register a brand of fertilizer for sale in the State that the "fertilizer contains no horn, hoof, hair, feathers, or other similarly inert nitrogenous matter," and requires the manufacturer or seller to "state the sources of the constituents of the brand of fertilizer offered for registration, which statement and the information contained therein shall be recorded for reference, and shall not be disclosed by the State director unless the materials used are such as are liable to lower the standard of the fertilizer or give it deleterious properties."

Everyone who has given any thought to the matter realizes the woeful confusion and lack of intelligent control there is in our fertilizer practice. This is due solely to our lack of knowledge of the real functions of fertilizers. We buy what is offered to us on a basis of the percentage of potash, nitrogen, and phosphoric acid, without a knowledge of the character of the ingredients. The manufacturer and dealer offer us the best they can, and their goods are nearly always up to the guaranty so far as plant-food elements are concerned, but neither the manufacturer knows, nor do we who make the purchase know, what carrier the element should be in to suit our particular needs. If we did know the manufacturer would only be too glad to furnish the actual kind of material needed for our soil and crop. It would cost him no more in the long run and would be better business and give more satisfaction all around.

The experience of farmers and the results of scientific investigation show that both the material and the proportion of the different materials in a mixed fertilizer may have an important influence on the results for any particular soil, so that it would seem highly important that each brand of fertilizer should have a guarantee as to the kind and amount of each ingredient in which the desirable plant-food ingredient is carried. We already know some of the principles which should guide us in the selection of materials for some of our soils and crops, and it does not seem impossible for us to extend our knowledge greatly along these lines, now that we are beginning to comprehend the problem and the function and the mode of action of fertilizers.

To show how hopelessly confused our fertilizer practice is at present and the great need for straightening the matter out, let us carefully analyze the situation in a single State, as contained in an official report of the North Carolina department of agriculture for the year 1907. There were 1,575 brands of fertilizers registered under the law for sale in the State. These were accredited to 113 manufacturers, and practically all of them came up to the guarantees so far as the plant-food elements were concerned. Considering the guarantees as correct, 720 brands, or 52 per cent, contained 8 per cent of phosphoric acid; 96 brands, or 7 per cent, contained 9 per cent of phosphoric acid; and 206 brands, or 15 per cent, contained 10 per cent of phosphoric acid. About 75 per cent of the brands, therefore, contained from 8 to 10 per cent of phosphoric acid.

There were 505 brands, or 54 per cent, containing 2 per cent of ammonia; 229 brands, or 24 per cent, containing 3 per cent of ammonia; and 103 brands, or 11 per cent, containing 4 per cent of ammonia. That is, about 90 per cent of all mixtures containing ammonia had from 2 to 4 per cent of this substance.

Of the mixtures containing potash, 445 brands, or 37 per cent, contained 2 per cent; 266 brands, or 22 per cent, contained 3 per cent; and 180 brands, or 15 per cent, contained 4 per cent of potash. That is, about 75 per cent of the mixtures containing potash contained from 2 to 4 per cent of this substance.

It will be seen, therefore, that in a large proportion of the mixtures the amount of the plant-food elements varied only 2 parts in 100—a rather small variation in fact—but we must remember there is also possibly a large, although entirely unknown, variation in the nature and possible efficiency of the compounds or substances carrying the element.

Considering now the complete fertilizers containing all three of the plant-food elements, of which there were 962 brands registered, it appears that there were 245 brands, or 25 per cent, which had the formula 8–2–2 per cent of phosphoric acid, ammonia, and potash, respectively; 134 brands, or 14 per cent, with the formula 8–3–3; and 33 brands, or 3 per cent, with the formula 8–4–4, or 412 brands, or 42 per cent, made up of these three simple formulæ. Do the 245 brands of the formula 8–2–2 really represent different fertilizers having differences which are apparent on different soils? Doubtless they do, for it is not only apparent from the figures given, but it is an actual fact that some of the manufacturers put out a number of brands under different trade names having the same formula, so far as the guaranty shows. Furthermore, it is the experience of farmers that these brands do differ in their effects on the soil. If these differences do exist, it must be due to differences in the materials used or in the way they are prepared and mixed.

It is important, therefore, that the substances used in the preparation of the fertilizers be stated by the manufacturer and be guaranteed in some way, so that each farmer may know exactly what substances he is buying in purchasing mixed fertilizers.

The uncertainty in our fertilizer practice is more fully exemplified in the formulæ presented to us by the manufacturers of fertilizers for the growing of special crops, which is, of course, the highest test of fertilizer production and which should give from experience and study the most exact knowledge.

There were 144 registered brands for tobacco in the North Carolina report. In these phosphoric acid ranged from 4 to 9 per cent, ammonia from 2 to 5 per cent, and potash from 2 to 10 per cent—very wide variations it must be admitted. Seventy-seven of these brands had the following formulæ:

30 brands, or 20 per cent	8–2–2
19 brands, or 13 per cent	8–2–3
43 brands, or 30 per cent	8–3–3
11 brands, or 8 per cent	9–2–2
8 brands, or 6 per cent	9–3–3

There were 79 special brands for cotton. In this list the phosphoric acid content ranged from 8 to 10 per cent, ammonia from 2 to 4 per cent, and potash from 1 to 4 per cent. Eighty-four per cent of the brands had the following four formulæ:

10 brands, or 13 per cent ---------- 8–2–1
29 brands, or 37 per cent ---------- 8–2–2
17 brands, or 21 per cent ---------- 8–3–3
10 brands, or 13 per cent ---------- 9–2–2

The variation in composition of the special brands recommended for truck, potatoes, grain, and corn is so great that they can not be grouped in any orderly way, under a few heads, as the above. The results, therefore, are given in the following tables, in which the first column indicates the percentage composition and the other columns the number of brands containing the different plant-food elements corresponding to the percentage shown in the first column.

There are 105 brands especially recommended for truck, as follows:

Per cent.	Phosphoric acid, No.	Ammonia, No.	Potash, No.
2	....	5	4
3	....	7	11
4	2	19	14
5	8	35	37
6	26	5	6
7	34	23	20
8	32	1	9
9	....	....	1
10	1	10	4

There are 63 special brands for potatoes, as follows:

Per cent.	Phosphoric acid, No.	Ammonia, No.	Potash, No.
1	....	....	1
2	....	11	1
3	1	4	5
4	2	7	5
5	4	21	16
6	20	2	6
7	18	16	20
8	15	....	5
10	2	....	4

There are 53 special brands for grain, as follows:

Per cent.	Phosphoric acid, No.	Ammonia, No.	Potash, No.
1	....	....	3
2	....	13	23
3	....	2	6
4	....	....	20
7	....	....	1
8	24	....	....
9	1	....	....
10	25	....	....
11	1	....	....
12	1	....	....

There are 9 special brands for corn, as follows:

Per cent.	Phosphoric Acid, No.	Ammonia, No.	Potash, No.
2	....	4	7
3	....	1	1
7	....	....	1
8	5	....	....
10	4	....	....

How can the farmers select with judgment the fertilizer suited to their own particular farms from the 1,575 brands offered for sale in the State of North Carolina? It requires no words of comment to show the need of a thorough investigation on this subject.

It will be remembered that from the investigations of the Bureau of Soils only 4 per cent of the soils examined gave the highest increase of growth with chemicals, the other 96 per cent giving better results with manure and cowpeas, and yet our farmers are spending in the neighborhood of $100,000,000 for commercial fertilizers made up in large part of mineral substances.

The investigations of the Bureau of Soils indicate that the fertilizer requirements do not follow, except in a most general way, the great soil types, but depend more upon the cultivation and previous cropping of the soil, so that it is a problem of the farmer or of the larger community where similar practices prevail.

Knowing as we now do that the fertility of the soil is largely influenced by the cultivation the soil has received and by the previous cropping, which leaves the soil in a more or less unsanitary condition, the investigation should be extended to certain typical soil conditions, which should be tested to show efficiency of each fertilizer substance and various combinations of them for such crops as it is proposed to grow. There seems no better way to carry on the preliminary investigations than with the wire-pot method devised by the Bureau of Soils, and there could well be cooperation in this work between the farmers and the experiment stations and the Bureau of Soils in an earnest endeavor to straighten out this large and important subject.

The method for determining the fertilizer requirements with wire pots is simple and direct, as the effects of treatment are shown by the plants themselves; but the taking of samples of soil requires judgment, as every spot where the small sample is taken, as well as the time of year or character of the season when the sample is taken, may influence the result. The sample should be taken at as near as possible the time when fertilizers are to be applied to the field and should be tested before it has had time to dry out. This throws the work all into a very short space of time in the very busiest part of the year. The ultimate and only really conclusive test, however, of the fertilizer requirements of any particular soil is the actual field test on the farm or on a small plot, and a number of State experiment stations and State departments of agriculture, among them the North Carolina department of agriculture, realizing the importance of this matter, have inaugurated a very wise system of test farms, located on the important soil types of the State.

SOME FACTORS IN CROP ROTATION.

The benefit derived from a suitable rotation of crops in maintaining the fertility of the soil has been known and has been commented on from the earliest historical times.[a] The first serious consideration of the reason for this seems to have been given by De Candolle, who reached the conclusion or announced the opinion that the deterioration of soils seen in the continuous cultivation of the same crop was due to a poison which the plant excreted and which, accumulating in the soil, made the conditions less comfortable for succeeding crops of the same kind, but was without such toxic effects toward plants of a different order. Liebig at first thought that this was the only scientific explanation that could be adduced for the beneficial effects of rotation. Later, after working out his mineral theory of plant growth, he gave as his conclusion that plants distort the ratio of plant food and so effect their gradual starvation, unless time is given for the soils to weather or another crop with different plant-food requirements is grown on the soil in rotation to restore the proper balance in the ratio for the first crop.

Without entering into the evidence which can be adduced to show the insufficiency of Liebig's views, it will suffice to say that no direct proof of Liebig's contention has ever been presented. De Candolle's hypothesis has been exhaustively investigated, and there is no reason to doubt that organic substances are excreted by plants or formed by bacteria associated with specific crops which do become toxic under certain soil conditions.

It is always permissible and generally easier in a scientific investigation to work from the most pronounced cases, where the phenomena are usually more easily found and less liable to be masked by other conditions which may or may not be effective.

---

[a] A. B. Griffith states in "A Treatise on Manures," third edition, page 3, that twenty-eight years after the publication of Sir Anthony Fitzherbert's "Ye Boke of Husbandrie," the earliest English work (1534) of any importance on agriculture, Martin Tusser published his famous "Five Hundred Points of Husbandrie," in which he strongly recommends the rotation of crops. He says:

> "Oates, rie or else barlie, and wheat that is gray,
> Brings land out of comfort, and soone to decay:
> One after another, no comfort betweene
> Is crop upon crop, as will quickly be seene,
> Still crop upon crop many farmers do take,
> And reape little profit for greedinesse sake."

Such marked conditions of the rapid decline of soil fertility are by no means uncommon in field experience. On certain recently reclaimed muck soils of northern Illinois, Michigan, and Wisconsin corn produces bountiful yields the first year. With two or three successive crops of corn without manurial treatment the yield decreases until it is no longer profitable to grow corn on these soils. It has indeed been found that with abundant applications of stable manure or certain potash salts this rapid deterioration may be prevented or the soils which have lost their power of producing profitable crops can be restored. On such virgin soils it is inconceivable that a crop or two of corn can either exhaust the potash or can so change the ratio of plant food as to cause this notable decrease in soil fertility.

On the reclaimed peat lands of the Stockton area, California, potatoes give a yield of upward of 400 bushels per acre for the first crop. In two or three years' continuous cultivation to potatoes the yield is reduced to about 40 bushels per acre, although the fertility as regards barley has not been noticeably affected. It is a very common experience with flax growers throughout the world that flax is a very exhausting crop for the soil and that satisfactory crops can not be maintained for more than two or three years upon soils continuously cultivated to this crop, but that a flax-sick soil is not sensibly impaired for wheat or other crops than flax.

Throughout the Eastern States, as well as in many of the countries of northern Europe, clover-sick soils are common where, without any apparent disease in the crop, clover refuses longer to grow under the usual methods of cultivation. Such clover-sick soils are not noticeably injured for other crops to which the soil is adapted, except through the absence of a leguminous crop in the usual rotation.

The deterioration of certain lands when continuously cropped to wheat, cowpeas, cotton, or to some of the truck crops, without systems of rotation or special treatment of the soil, is so well known and so often experienced as to make it unnecessary to cite specific cases.

Coming now to the results of laboratory investigations of this subject, it has been possible by growing successive crops of wheat in paraffin wire baskets until wheat will no longer grow upon the soil, or by growing wheat in pure nonnutrient agar jelly, to show that the plant excretes a crystalline organic body of known composition which was not present in the soil or in the agar before the wheat plants had grown in them. This organic body, when added to a culture medium, is toxic to wheat, but not toxic to cowpeas.

From a cowpea-sick soil produced by the continuous growth of cowpeas, under greenhouse conditions, has been obtained a pure crystalline organic body, not present in the soil before cropping, which is exceedingly toxic to cowpeas when mixed in otherwise good culture medium, but is not so toxic to wheat.

After the wheat has grown on the cowpea-sick soils and has been unharmed or even benefited by the previous cowpea growth, cowpeas can be again grown, and they in turn will be found to benefit by the activities of the wheat. Several organic bodies have been isolated from soils, some of them phosphorus compounds, nitrogen compounds, sulphur compounds, waxy and fatty bodies, so that a very wide range of organic bodies likely to result from metabolic changes and from soil conditions may be expected from further investigations of the chemistry of the organic matter of the soil. Whether these bodies are specific for each kind of plant we do not know, but it seems probable that either in the metabolic processes of the plant or from the changing conditions in the soil and climate they offer marked differences which will have to be further investigated.

It is very certain also that in many soils these bodies do not persist for any great length of time. They are all likely to change through oxidation and fermentation into intermediate toxic or nontoxic bodies, and finally, under the very best soil conditions, into inert black humus bodies. Some of these organic bodies, at least under certain soil conditions, appear to be stable for a great length of time, as we have infertile soils which have not been productive within the memory of man. Some of these organic bodies seem to be toxic to all of our cultivated crops. Many of them appear to be less toxic to some crops than to others or even beneficial to some crops.

With substances of the first class, which appear to be toxic to all crops, it will be necessary to remove or destroy them before the productivity of the soil can be renewed. With bodies of the second class, especially such as are beneficial to some plants, the object should not be to destroy unnecessarily, but to benefit by their presence by the growing in rotation of such crops as the conditions would seem to be adapted to. In the change or destruction of these organic bodies the first principle of soil management, viz. the cultivation of the soil is the most important, as, aiding in fermentation, it induces changes which as a rule are highly beneficial.

The breaking down of these organic bodies through fermentation brought about by cultivation of the soil is usually markedly hastened by an application of easily decomposing material like stable manure or green manure, for in the process of decay of this very unstable material the destruction of the more stable forms of organic matter in the soil is facilitated. Less efficient, but still very important and often more economical, agencies in the destruction of the organic bodies—of the changing of the toxic into nontoxic forms—are found in the commercial fertilizers. Some of these fertilizer effects are now fairly well understood, but a great amount of research yet remains to be done before this subject of fertilization will be sufficiently well understood to make the practice much more sure and more economical than it is at present. It is now known that, at least under certain conditions which have been studied, fertilizers and crops together may do more than either by themselves, and that certain fertilizers may have their place in the crop rotation. This accords with experience, which has shown that fertilizers give better results with some crops than with others in the rotation system.

It is not presumed that the principles of crop rotation can yet be worked out in a scientific manner for all crops, or under all soil and climatic conditions, but enough has been given in this rapid sketch of some of the principles of rotation, brought out in the course of our investigations, to show a wide field of inquiry. With further work along this line, using methods now being developed, the real principles of crop rotation can probably be worked out.

FACTS REGARDING SOIL DETERIORATION.

There are in the United States soils which, so far as known and within historic times, have never been productive, although under climatic conditions favorable for crops. Besides some of the very dry coarse sands and gravel we have as examples the Elmwood loam of Connecticut, the Conowingo loam of North Carolina, the Monroe silt loam of Louisiana, and the scrub lands of Florida. Other soils are noted for their great and lasting fertility. Examples of this class are the Dunkirk soils of New York, the Hagerstown soils of Pennsylvania, Maryland, and the Valley of Virginia, and of the blue-grass region of Kentucky, the Marshall soils of Iowa, the Houston soils of Alabama, and the Yazoo soils of the Mississippi Valley. Other soils, again, forming an intermediate class, originally very productive, have deteriorated in yield until they are now relatively unproductive. Notable among these are the Cecil soils of Virginia, North Carolina, South Carolina, and Georgia, some of the Norfolk soils of Maryland and Virginia, and the Portsmouth silt loam of North Carolina. It has been the general custom in some parts of the country to crop fields in single crops until they become so unproductive that they are abandoned to forest growth and new lands are taken up.

Soils vary greatly in their powers of endurance. We have deep, rich soils and we have thin, poor lands. We have black soils which are nearly always more productive and more lasting than white soils and we have the red soils which are generally more productive than the yellow soils.

Most soils deteriorate through neglect and insufficient and injudicious cultivation. It is a general experience that soils deteriorate under tenant farmers, who have little interest in the welfare of the farm beyond the year of certain occupation and little capital and insufficient stock to work it with. Such cases are seen in almost all communities, where individual farms or even settlements have deteriorated, while the surrounding fields under better management maintain their fertility.

Soils also deteriorate even with fairly good treatment when continuously cultivated in one crop, whether it be cotton, wheat, corn, or tobacco. There are soils like the Marshall soils of the prairie regions and the Houston and Yazoo soils of the South which appear to be notable exceptions to this, but we of the United States are beginning to realize very generally, what older countries have known for generations, that it is neither safe nor judicious to have a one-crop system on any of our fields, or at least that such a system should not be continued long with annual crops.

Certain soils deteriorate quickly through natural but obscure causes, even with the best attention to cultivation. Some of the reclaimed muck soils of Illinois and Wisconsin, as noted in another connection, produce one or two large crops of corn and then produce little or no yields unless the soil is heavily manured or treated with a potash fertilizer. Some of the reclaimed muck soils of California yield one or two large crops of potatoes and then fail completely to produce a third successive crop, although the power to produce barley is unimpaired. Flax is considered one of the most exhaustive crops, as but two or three successive crops can be taken from the same land, although wheat will produce normal crops after the flax fails. Again, in forcing vegetables and flowers in greenhouse work the soil quickly becomes unable to support the continuous growth of a certain plant, in spite of the liberal use of manure and fertilizers, although it may still be just as well adapted to different kinds of crops.

Soils, of course, frequently deteriorate through erosion where the top soil is removed, leaving the infertile subsoil as the medium of growth. Examples of this are frequently seen in the Cecil soils of the Piedmont Plateau.

To show how easy it is to lower the power of a soil to support growth with continuous culture in the same crop, take one of the little paraffin pots used by the Bureau of Soils in fertility studies and put in about a pound of soil of average fertility. Plant six wheat seeds and let the seedlings grow for two or three weeks, when their roots will have permeated the soil. Then cut the plants off and replant as before. Also put up a pot of the fresh soil and plant this in like manner. Most soils so treated will yield plants only about half as large for the second crop as for the first. The fact is very interesting and suggestive and the experiment is very instructive. The reason for this and the remedial measures to prevent this deterioration will be referred to later.

Soils generally are benefited by resting, as illustrated by the old English system of fallow, under which, with occasional stirring, the best conditions are presented for oxidation and fermentation of the organic bodies left in the soil as a result of the last crop. Rotation has almost entirely taken the place of fallow and seems to be better for the soil, indicating that certain plants themselves assist in the improvement of soil conditions after another plant of a different kind has occupied the land.

A severe and long-continued drought also usually leaves the soil in excellent shape for a crop the following season, indicating that a complete drying out of the soil for a prolonged period brings about beneficial changes in the soil. Indeed, in keeping soils of poor or average fertility in an air-dry condition in the laboratory for several months they usually are found more productive when tested with plants again.

Again, soils temporarily impaired in productive capacity are usually restored by a reversion to forest growth, although this takes some years. It has been a common practice in the South when, with the continuous clean cultivation of cotton, the soil becomes quite unproductive to turn it out and let it grow up in old-field pine or oak and take up new land, which in fact may have been used years before.

In growing tobacco in Sumatra, it has been found necessary, in order to maintain the finest quality of leaf, to use only land freshly cleared of the jungle. After the one crop has been secured the land is allowed again to grow up to jungle for ten or fifteen years before another crop is planted.

CAUSES OF SOIL DETERIORATION.

Investigations have shown that there are sufficient quantities of the mineral plant-food constituents in the soil moisture to produce good crops, that the supply is maintained from the continuous solution of the minerals of all ordinary soils throughout the growth of the crop, and that there is a ready movement of this moisture under optimum conditions to supply plants with both minerals and water. To what, then, can infertility be due when the physical conditions of the soil are in themselves favorable to plant growth?

It has been stated that if some soil of average fertility is put into one of the little paraffin wire pots and wheat seedlings grown for two or three weeks and then cut off and a second crop immediately planted, the second crop will make only about half the growth it would in a fresh sample of the soil. The first crop has evidently exhausted the soil. If we take this soil which has just had wheat seedlings growing in it, or some soil from an "exhausted" field, and make an extract with water, at the same time making an extract in the same way of a sample of fresh or productive soil, we will find from analysis about the same amount of mineral plant food in both solutions. If we now grow seedling wheat plants in these solutions, we shall get a much larger growth in the extract from the fresh or fertile soil than in the other. So we have transmitted the properties causing infertility from the soil to the extract. If, now, to the extract from the poor soil, we add fertilizers, we may find that the plants will grow as well as in the extract from the good soil. This would look on the face of it as if infertility were due to a lack of plant food, in spite of the results of the chemical analysis. But if we add certain organic substances which are easily oxidized or reduced and which contain no mineral plant food at all, or if we add solid and insoluble absorbing agents, like carbon black or absorbent cotton, and filter the solution away from them, then the plants will grow equally as well as in the extract from the good soil or as in the extract from the poor soil to which fertilizers have been added. This proves that it is something present in the extract, rather than the lack of something needed by the plants, that retarded growth. Finally, in a soil in which wheat has recently grown we have been able to separate a crystalline organic substance which was not present in the soil before the wheat was planted. This substance is toxic to wheat plants and if present in the extracts or in the soil in certain concentration will kill the plants and in smaller proportions will retard their growth and cause infertility. We have proved in this way, by a large amount of investigative work upon worn-out soils from all parts of the country, that infertility is often due to the presence of toxic organic bodies in the soil, either excreted by the previous crops or perhaps formed by the action of bacteria, molds, or ferments from the plant remains.

NATURE AND PROPERTIES OF TOXIC BODIES.

These toxic bodies are organic. They may be fatty bodies, nitrogenous bodies, or nonnitrogenous. They appear to be quite unstable in the soil, changing rather easily by oxidation into harmless or even into beneficial bodies. They are not equally harmful to all plants. The product from cowpea soil, which has been obtained in pure crystalline form, while toxic to cowpeas is not so harmful to wheat, and with wheat growing in the solution the body appears to be decomposed, and the solution or the soil after the wheat is again suitable for cowpeas. This is believed to be the result of oxidation, and the experiment proves that this may be aided by plants themselves and still more by plants and fertilizers together. Bacteria also aid in this oxidation or reduction of the toxic bodies, especially if only a small quantity be present. Some of the mineral salts of these toxic bodies are quite harmless, and fertilizers may aid by going into combination with these organic bodies.

POSSIBLE MEANS OF AMELIORATION.

Knowing the nature of the trouble, the source in some cases at least, and the properties of the toxic substances, we are prepared intelligently to provide means for the amelioration of the soil conditions. We know that these toxic bodies are more apt to form and accumulate or less likely to change where aeration is deficient, as in an overwet soil; so when such conditions prevail we must provide better aeration by thorough underdrainage. We know that the proper fermentation of organic matters does not proceed well with too much aeration; hence the need for compacting a very loose soil.

Cultivation of itself, and especially if accompanied by a light dressing of decomposed organic manure, tends to hasten oxidation. But deep cultivation must not be too frequent.

In improving a loam soil which is raw and unproductive, put on a light top dressing of well-rotted manure and turn it under about 3 or 4 inches deep. Let this stand four weeks to ferment, then turn it over about 2 inches deeper; then plant a crop—rye or cowpeas if the soil is very poor. With such treatment the soil will gradually darken throughout, although it may take two or three years to bring it up to a fair state of fertility. The change in condition will be evident to the eye. Each type of soil will, however, require somewhat different treatment, and the method of cultivation adapted to one soil will not perhaps be suited to another. Judgment and experience is required in the cultivation of an infertile soil with a view to improving it, even more than in maintaining the fertility of a productive soil.

The improvement of an infertile soil or the changing of a raw subsoil into a true soil involves a fermentation of organic matter to produce other and more stable compounds, just as in the fermentation of tobacco to produce quality in the leaf, the fermentation of malt, the ripening of cheese and of fruits, and the "raising" of bread. Cigar tobacco will not develop aroma by hanging in a barn in contact with air. It must be put into a bulk, built neither too compactly nor too loosely, and the amount of moisture, temperature, and aeration must be carefully regulated, with respect to the peculiar character of the leaf and the purposes for which it is intended, to get the best results. So in the proper fermentation of the organic matter of the soils we must study more the laws and conditions of fermentation, and we must realize that this is greatly aided by enzymes and plant life itself, either by the lower bacterial forms or by the higher forms—the crops and even the weeds and other native vegetation. Cultivation thus appears a great subject for investigation, which, as our methods of soil investigation are becoming more perfect, can probably soon be taken up and worked out.

After cultivation the most important thing is the selection of the proper crop, even of the proper variety of any particular crop and the proper rotation of the selected varieties. This will undoubtedly aid in improving a soil, for reasons which we have seen, and more often still it will prevent soil deterioration. No exact or thoroughly satisfactory system of crop rotation has yet been worked out for any particular soil, and it is time the subject was taken up and studied by thoroughly trained scientific investigators.

After cultivation and rotation we have fertilization as an important and powerful factor, if properly used, in soil improvement, commercial fertilizers, stable manure, and green manures each having an important place in the general scheme. The proper crop rotation and the fertilizer treatment for a soil can probably be best worked out empirically by the paraffin wire-pot method, supplemented by field trials.

We have, then, proper drainage, cultivation, aeration, rotation, and fertilization, all acting to the same end, namely, the maintenance of sanitary conditions in the soil to increase the productive capacity of worn-out lands.

PERMANENCY OF SOIL FERTILITY AS A NATIONAL ASSET.

The soil is the one indestructible, immutable asset that the Nation possesses. It is the one resource that can not be exhausted; that can not be used up. The general conception of the exhaustion of soils is that the crop removes plant food, and that unless we return some considerable portion of plant food to the soil it eventually becomes incapable of longer producing adequate crops. To quote from a recent article in one of the agricultural journals:

> We have warned our readers for the last ten years of what is coming if they continue to grow grain crops and sell them off the farm continuously from year to year. * * * Don't imagine for one minute that your soils are of inexhaustible fertility. No such soils were ever made in the Western Hemisphere, except, perhaps, such as are enriched by overflow every three or four years.

The impression prevails that our crops take out phosphoric acid, potash, and nitrates to such an extent that the soil becomes incapable of longer supplying these plant-food constituents for a satisfactory yield. Several articles have been written recently, calling attention to the calamity which is likely to confront us in a few years because of the exhaustion of one or more of the elements of plant food if the present practices are continued.

Sir William Crookes, president of the British Association for the Advancement of Science, takes a very gloomy view of our ability to continue any longer to obtain from natural sources sufficient nitrates to replenish the diminishing supply of nitrates in our soils. More recently, even, the question of the exhaustion of phosphates from the soils of southern Illinois has been considered, and we are told that the supply is only sufficient for about seventy crops such as are now being harvested. Gloomy indeed are some of the predictions that are being made in regard to the probable failure of the soil to support the increasing population of the earth. In an article on the "Effect of Milk Selling on the Soil," in the Agricultural Gazette, November 7, 1904, Mr. John Wrightson, in reference to a previous article in the same journal, says:

> In the transactions of the Highland Agricultural Society he will find papers upon the serious injury to the highland sheep walks due to the constant drain upon them of phosphates through the continuous sale of lambs. The fact is that both in the highlands of Scotland and in the United States of America the stock lands have been in many cases ruined, or are in process of being ruined, simply by the annual depletion of phosphates. These cases are parallel with the sale of milk, as bone earth (phosphate of lime) is an important constituent of the milk.

In the same publication, November 14, 1904, Primrose McConnell replies to Mr. Wrightson in the following language:

> It is rather strange at this time of day, after all that has been said and written on the subject, to find anyone harking back to the old fallacy that the keeping of milch cows impoverishes the land. In Cheshire dairying has been carried on for seven centuries, yet a small dressing of bones renovated the pastures within our times. In my native county of Ayr dairying has been carried on for two and a half centuries, yet I have never heard of any impoverishment, but the contrary, and I affirm that if any alleged case of impoverishment is inquired into it will be found to be either mythical or due to exceptionally bad management. In my own case, where twenty years ago it took 2½ acres to graze a cow during the summer, those same fields now require 1½ acres to do the same, and on one occasion 1 acre per head was sufficient—their droppings have so enriched the land.

To show why the Bureau of Soils believes the direful predictions of the exhaustion of soils are unfounded, and why we have come to believe that the soil is indestructible and in the main unchangeable, except through our gross neglect, it will be well to discuss some of the supposed cases of soil exhaustion in this country.

SOME SUPPOSED CASES OF SOIL EXHAUSTION.

The Division of Soils, now the Bureau of Soils, was organized about twelve years ago for the study of the soil resources and the soil conditions of the United States. One of the important works undertaken by the bureau was the soil survey, and this has been continued now for about eight years, during which time over 147,000 square miles have been mapped in representative districts throughout the country. It was from the first realized that in surveying and mapping the soils it would become necessary to study for our farmers some of the great soil problems encountered in the areas, especially such as concerned the management of the soil and the production of larger crops on certain soils.

There has been an impression for years that our virgin prairie soils are becoming exhausted. There is an impression in other sections of the country that the continued use of fertilizers has injured the land. We have seen in the last few years rural sections of the country almost depopulated and a disquieting increase of abandoned farms. Involved in these beliefs and changes appeared to be problems of great National importance.

Some years ago, through an arrangement with the Virginia Board of Agriculture, the Bureau of Soils made quite an extensive investigation of the soils of Virginia. Attention was called at that time to the poor soil condition in certain sections of the State, particularly in middle Virginia, where it appeared that the soils once fertile had worn out; that they had become exhausted. There was at least truth in the claim that agriculture had declined. Later, when we were preparing to take up some important problems in soil fertility, middle Virginia suggested itself as a locality where the Bureau might do some effective work on soils which by general consent had reached about the lowest possible stage of crop production through an actual exhaustion of plant food. In a report covering this area it was subsequently shown that conditions have markedly improved; that the crop yields on most of the soils are now fairly satisfactory, and that good methods of cultivation and attention to crop rotation, together with the introduction of more live stock and the utilization of the manure produced, will unquestionably in a short time bring this area up to a really satisfactory condition. There appears, therefore, to be no problem presented here of an actual exhaustion of the mineral plant food of the soil, as a mere change of cultural methods has been sufficient to increase the general productivity of the soil of the area in from eight to ten years.

In 1901 a soil survey was made of Prince George County, Md., and the general impression at that time was that these soils had become so far exhausted that the yields were unsatisfactory. This was another area considered as a suitable locality for investigating the actual exhaustion of plant food from a soil. The opinion of the Bureau, however, has been that these soils were not exhausted of their plant food, but were still capable of producing satisfactory crops with improved methods and with proper crop rotations, and this proved to be the case, for it was found that within a period of less than five years the methods had already been improved, and that the crop yields were much better than formerly. There is thus every reason to believe that with better methods of cultivation, more attention to crop rotation, and the introduction of live stock the problem of the fertility of these soils will be satisfactorily worked out. This would indicate that the unproductiveness of lands in the condition presented in 1901, when the survey was made, is not due to an actual exhaustion of plant food, but to some other cause or causes which deserve consideration.

For three years, under orders from the Secretary, the Bureau of Soils had one of its men detailed as an instructor in soils at Cornell University. We had heard a good deal of the abandoned farms in portions of Tompkins County, N. Y., in which Ithaca is located. Upon looking into this matter we could find no evidence that the crop yields were less now than they were years ago. There were abandoned farms, but this was due to other conditions than the exhaustion of the soil.

Another problem presented itself in the abandoned farms of New England. So a soil survey party was sent into Merrimack County, N. H., where many farms were reported as being abandoned, the country generally having gone backward as an agricultural community, and where the question of reforesting was being agitated. These men reported the soils in good condition, the yields good, and no evidence could be found in that particular region of any general deterioration so far as the soil is concerned.

About six years ago the Industrial Commission held hearings in regard to the causes leading up to the abandonment of farms. This subject was treated rather exhaustively, and a report (No. 70, of the Department of Agriculture) was published giving the testimony. As this report is available, the principal contributing causes only will be given here. These are the development of new areas and new industries; the introduction of farm machinery incapable of being used in certain districts; attempts to grow crops unsuited to particular soils; unfavorable climatic conditions; scarcity of water in desert country; alkali and seepage water; flooding and inundations by storms and tides; labor and expense of maintaining proper physical conditions; transportation conditions; social conditions; deterioration of farms through improper methods of cultivation; injudicious crop rotation.

It appears, therefore, that this great problem which has presented itself in different parts of our country—the abandonment of farms—is due not to the exhaustion of the soil, but to other conditions—mainly social and labor conditions.

In 1906 the bureau had a soil-survey party in Blue Earth County, Minn., in one of the wheat areas of that State, and the men reported that it was generally believed that, owing to the exhaustion of the soils, the yields of wheat had decreased from 30 to 40 bushels per acre fifteen years ago to 12 bushels per acre now. The belief that the prairie soils of the West have deteriorated is very widespread, not only in this country, but also abroad. There is constant reference to this fact in the agricultural literature and in the scientific journals of this country and of Europe. The Bureau had the records examined to see if undoubted statistical evidence that the soils had deteriorated could be found, using the crop as a measure of the soil fertility. It was found that the available statistics—running back to the year 1874 and up to 1898, a period of twenty-five years—for four typical wheat counties in Minnesota, three of them in the Red River Valley, and also for the State at large, showed no evidence of a decline in yield, but on the contrary only that fluctuation due to seasonal differences. The yearly records fail to show the large yields in the past that we are accustomed to attribute to those soils. The yields for Blue Earth County itself, as well as for the three typical wheat counties of the Red River Valley and for the State at large, are shown in the following table:

Yield per acre of wheat in the State and several counties of Minnesota.

Year.	Kitson County.	Polk County.	Clay County.	Blue Earth County.	Average for State.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1874	....	8.87	....	12.83	14.23
1875	....	17.25	14.69	13.51	17.05
1876	....	11.75	5.49	18.87	9.61
1877	....	25.19	16.85	16.35	16.79
1878	....	....	....	....	12.50
1879	22.92	16.88	16.13	8.14	11.30
1880	19.10	16.40	16.87	13.43	13.30
1881	18.79	17.55	17.18	6.74	11.42
1882	21.78	15.11	16.03	14.00	13.81
1883	15.18	14.22	15.09	13.53	14.37
1884	21.21	16.18	13.87	17.31	16.35
1885	14.30	13.40	9.20	16.90	13.55
1886	13.80	15.10	22.10	17.20	15.80
1887	25.70	18.30	12.40	18.40	....
1888	....	10.00	12.00	....	....
1889	....	....	....	26.90	15.30
1890	....	13.50	13.70	13.30	13.00
1891	....	....	....	17.40	18.10
1892	3.20	....	10.80	12.30	11.80
1893	15.00	....	9.40	12.00	10.70
1894	19.30	11.70	10.50	12.90	13.00
1895	27.00	20.10	19.90	19.40	18.53
1896	7.70	12.00	13.20	....	12.80
1897	14.33	12.00	11.02	17.20	9.11
1898	15.43	12.00	11.24	....	....

So far as our researches have gone, and so far as we can rely upon statistics of this kind—and we have not gone beyond the simple returns that have been published—it seems to us that the general impression of the deterioration of soils, the general idea that has been held about soil exhaustion due to an actual exhaustion of available plant food, is erroneous.[a] It will be shown later that the

[a] This subject is being treated much more exhaustively for the National Conservation Commission, and this conclusion is being confirmed and strengthened.

soil can be abused; that there is no question that the yield will deteriorate with improper methods of cultivation and with improper systems of crop rotation, but in a large area, such as a county or a State, there are other factors of changing owners and different usages which may influence the final results and make the actual statistics more uniform than we would expect from the records of a few individual farms. When the land becomes unproductive it is thrown out of cultivation, and when it is taken up again for cultivation it is found to be improved.

It is hardly necessary for me to refer to the fact that we have erroneous impressions in regard to events that have taken place in the past. In a recent number of the Monthly Weather Review [a] there is a very able article entitled "Present Day Climates in their Time Relation," by Prof. Frank Morris Ball, of the Department of Geology, University of Minnesota, in which he says:

It is often asserted by people who have lived in a locality for many years that the climate of their region has undergone marked changes during their residence, the most common statements being that cold weather came earlier in the fall; that greater snowfall was experienced; that the thermometer registered more continuously low temperature in years past than at present, and that the rainfall is increasing or decreasing in amount. In the light of modern science such statements are open to serious question. The human organism is at best an inaccurate register of temperature, and memory is more liable to be impressed with some single manifestation of weather than with the average of weather conditions which go to make up climate. A vivid impression of a day on which the thermometer registered 40° below zero is quite likely to remain in the mind for a long time, but the week of moderately cold weather which followed the cold snap and which, when averaged with the lowest temperature noted, made only average winter weather, is quite likely to be unnoticed, or, if noted at all, soon forgotten. * * * If we stop a moment to reflect that the factors of climate are under the direct control of natural laws, no surprise will be occasioned because of the permanency of climatic averages. That seemingly most willful and lawless of all elements, the wind, is no less under the direct control of law, and responds to it with no less unhesitating obedience than does the earth to the law of gravity in its yearly swing around the sun.

The last paragraph of this article is particularly important:

No better proof of the relative nature of all human knowledge and the temporary character of all human conclusions can be found than in the above paragraph. The most elementary knowledge of geology and related earth sciences is sufficient to prove that climates have changed many times in the geologic ages through which the earth has passed. All theories accounting for such changes lead irresistibly to the conclusion that climates to-day must be changing, although not in any measurable amount.

There is no question that our soils are changing, but to the finite extent of human knowledge it is very much to be doubted whether there have been any measurable fundamental chemical changes in the

---

[a] Volume 34, May, 1906.

mineral soil material of the lands that we actually cultivate, save such as are brought about by erosion by wind or water.

THE TRUE NATURE OF THE SOIL.

It has been taught that the soil results from the disintegration and decomposition of the minerals contained in the original rocks, and strong emphasis has been placed upon the decomposition of these minerals in the formation of soils. On the contrary, as has been shown in the first part of this bulletin, the soil is essentially an aggregation of mineral particles coming from the disintegration of rocks, and to some extent from the decomposition of the original minerals themselves, but one will find in all soils a large number of minerals which can be recognized as having been present in the original rocks. The older agricultural soils of Europe and of Asia contain the same common rock-forming minerals as the newer soils of the United States, and the chemical composition as determined by analysis of the mineral portion shows no essential differences. The fact that the lands of Europe have been occupied for one thousand years or more has not made a noticeable reduction of the plant food element as compared with the new soil of this country.

RELATION OF THE SOIL TO PLANT NUTRITION.

The old idea of soil fertility was that plants could not avail themselves of the potash or phosphoric acid until the rock particles, the minerals, were decomposed and their constituents made available to the plants. It is, however, merely a question of the solubility of the mineral particles themselves. One can take the minerals obtained from the soil, or minerals from museum collections, and by grinding them up and adding water and a little nitrate can get a soil solution which is comparable with the soil solutions of our fields, and can grow as good plants in the extract from the cabinet specimens so prepared as in the extract of the soils itself. The plants can avail themselves of the potash, phosphoric acid, and lime which are dissolved directly from these mineral particles. Not only so, but if we take these minerals and wash them by repeated leachings, we will continuously get quantities of potash, phosphoric acid, and lime dissolved in the water. After leaching repeatedly and frequently during the day, if we leave the particles in contact with a fresh portion of water overnight, in the morning the concentration of the solution will be about the same as it was the morning before, so immediate and rapid is the recovery and so adequate and ready is the supply of these mineral nutrients.

We have in our soil moisture a solution which carries sufficient mineral nutrients for the support of the plants. It is capable of maintaining its concentration by re-solution from the minerals to supply any portion of these plant food constituents that may be withdrawn. Under ordinary conditions of drainage and of rainfall the concentration can not get too large, nor can it for any considerable period get too small for the need of plants. In other words, we have in the soil a most efficient system for supplying the nutrient food for plants.

This, therefore, is the nature of the soil and of the soil moisture. It is a great nutrient medium for the support of plants, spread out over the surface of the earth, and as all soils, with but possibly few and unimportant exceptions, are made up of a great number of minerals, it follows that the concentration and the composition of the soil moisture in our different types of soil varies but little. One might expect to find that in such extreme cases as the heavy clay soils of the limestone Valley of Virginia, the black prairie soil of Texas, or the Norfolk sand of the Coastal Plains there would be marked differences in the composition of the soil moisture, but our investigations show that the moisture has about the same composition in each of these widely different types of soils, or at least such differences as do occur are not sufficient to explain the observed differences of crop adaption and yield.

HISTORICAL EVIDENCE THAT SOILS DO NOT WEAR OUT.

Attention will now be called to some very striking historical and statistical data that seem to prove that soils do not wear out, and inferentially that they will not wear out in finite time.

It has long been a mystery how soils have continued to support crops for a thousand years and more, and the mystery becomes deeper when we realize that in the oldest cultivated countries there is no sensible diminution of plant food. We have the general history of China that goes back probably for four thousand years. There are many sections of that country that have undoubtedly supported a population for at least as long a time as that. It is said that they are very careful to return the excrement both from man and animals to the soil, but there must be some loss, some waste, and in four thousand years this would amount to considerable. But there are no signs of deterioration of these soils. There is no evidence that these soils are going back, and the fact that they have been careful in their cultivation only goes to show what we could do with our soils if we exercised reasonable care.

Coming down to more recent times, of which we have actual statistical records, it can be shown that so far as statistics can be relied on, without going back of the returns, without finding out how these statistics were taken, and just what value they have, the soils of the world, or at least of the European countries, are not wearing out, but that they are actually improving.

Prof. Wilhelm Kellerman[a] in an article on the "Increase of Crop Production in Germany," published in one of the German scientific journals, has been fortunate enough to get the actual yields of some of the old German estates which have been handed down in the same families for a long period of years. The figures from three of these estates have been taken as illustrations that the yield in these older countries is not decreasing, that the lands are not becoming exhausted, but that, on the contrary, there has been a material increase in the production per acre. A record from one estate goes back to 1552. The period from 1552 to 1557, apparently the average for those years, gives a yield of wheat of 12.5 bushels per acre. In 1670 there is a record of 14.6 bushels, in 1822 of 18.7 bushels, in 1825 of 18.1 bushels, in 1840 of 25.6 bushels, in 1850 of 28.7 bushels, in 1880 of 35.3 bushels, in 1897 of 45.1 bushels, an increase in those three hundred years from 12.5 bushels in 1552 to 45.1 bushels in 1897, the record showing a regular increase, with a few fluctuations which are probably due to seasonal conditions.

Yield of cereals in Schmatzfeld, Germany.

Year.	Wheat.	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1552–1557	12.5	13.2	14.2	14.8	1840	25.6	30.0	31.6	45.5
1660	....	12.8	8.3	12.3	1850	28.7	33.1	39.3	50.1
1670	14.6	17.2	16.1	17.4	1860	35.3	39.3	32.9	62.9
1810	....	....	....	....	1870	27.6	20.4	45.8	46.6
1820	....	....	....	....	1886	37.9	28.9	43.2	66.6
1822	18.7	24.3	33.7	26.2	1887–1896	40.0	29.6	47.6	59.7
1825	18.1	20.0	28.1	32.5	1897–1904	46.1	34.0	50.4	69.1
1830	18.7	21.2	35.6	46.2					

From another estate records apparently even more complete are given in five and ten year periods from 1756 to 1904. The average yield of wheat in the first period reported (1756–1765) is 26 bushels; in the next period (1766–1775) it is 13 bushels; and from there on a gradual increase took place up to 1900–1904, when it was 36 bushels. Rye increased similarly by regular steps from 15.91 bushels to 32.52 bushels; barley from 14.25 bushels to 43.23 bushels; oats from 23.03 bushels to 57.80 bushels. The details are given in the accompanying table.

Yields of cereals on Rittergut Trebsen, near Leipzig.

Year.	Wheat.	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1756–1765	26.41	15.91	14.25	23.03	1825–1834	21.04	21.63	30.19	31.83
1766–1776	13.25	12.33	21.71	23.48	1835–1844	33.40	27.92	36.66	46.54
1776–1785	16.63	14.47	20.44	23.45	1845–1849	25.51	28.75	....	56.25
1786–1795	13.98	13.67	16.77	19.16	1883–1892	27.03	23.06	30.95	44.64
1796–1800	13.89	15.36	15.16	17.90	1893–1894	29.85	28.36	30.95	54.74
1814–1816	15.28	15.68	25.41	25.72	1895–1899	35.85	30.45	35.39	51.15
1820–1822	16.90	19.14	18.28	26.36	1900–1904	36.14	32.52	43.23	57.80

[a] Landw. Jahrb., 35, p. 289 (1906).

From a third estate records are available in ten-year averages from 1800 to 1894, and wheat has shown a continual increase from 21.15 to 35.70 bushels; rye from 14.64 to 29.52 bushels; barley from 19.8 to 41.06 bushels; oats from 17.22 to 43.96 bushels. The details are given in the accompanying table.

Yields of cereals on a German estate.

Year.	Wheat.	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1800–1810	21.15	14.64	19.80	17.22	1860–1865	29.77	30.48	37.85	44.52
1810–1820	20.02	11.76	20.92	13.44	1865–1870	27.45	26.48	36.17	55.72
1820–1830	23.25	17.76	21.29	14.84	1870–1875	29.92	28.32	35.71	51.38
1330–1840	18.82	15.04	16.37	13.86	1875–1880	28.12	24.32	29.38	39.48
1840–1850	23.10	19.84	20.83	27.58	1880–1885	25.57	25.12	36.45	45.08
1850–1855	26.40	23.12	32.75	33.46	1885–1894	35.70	29.52	41.06	43.96
1855–1860	25.27	24.16	27.71	34.44					

Professor Kellerman makes this very interesting assertion in his article:

If we now make a brief survey of the results obtained in the foregoing, we must affirm that the development of the yields of cultivated soil since the beginning of the past century presents a very pleasing picture. Not only that agriculture by absolute addition to the acreage of 30 to 35 per cent and decrease in fallow from 33 to 4½ per cent has tried to meet the growing need of the nation for food, but above all that it has shown how to gain from the soil gradually two and one-half times as much per unit of surface as formerly.

There is available in the report of the French minister of agriculture the yield of cereals for France from 1815 to 1876, and the figures show that during this period of fifty years wheat, rye, barley, and oats have all increased.

Yield of cereals in France.

Year.	Wheat.	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1815–1824	11.86	10.10	14.45	17.12	1855–1864	15.90	14.11	19.90	24.93
1825–1834	13.44	12.34	14.64	17.78	1865–1874	15.81	14.65	19.75	24.49
1835–1844	14.30	13.01	15.92	20.10	1875–1876	16.60	15.71	19.00	23.61

Wheat has increased from 11.86 to 16.60 bushels; rye from 10.1 to 15.7 bushels; barley 14.4 to 19 bushels; oats from 17.12 to 23.61 bushels.

Records are also available for Germany from 1881 to 1900, and during that time the yield of wheat has increased from 21.75 to 26.55 bushels; rye from 18.56 to 23.04 bushels; barley from 29.07 to 32.49 bushels; oats from 36.96 to 45.08 bushels. This is for the entire area of the German Empire. The details are given in the table on the following page.

Yield of cereals in Germany.

Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*
1881-1885	21.75	18.56	29.07	36.96
1886-1890	22.65	19.04	29.07	40.32
1891-1895	24.30	21.28	31.54	40.88
1896-1900	26.55	23.04	32.49	45.08

Statistics for the whole of Europe from 1876 to 1904 show a gradual increase in yield per acre of all cereal crops. Wheat has increased from 12.90 to 15 bushels; rye from 11.84 to 14.08 bushels; barley from 17.86 to 18.62 bushels; oats from 24.08 to 27.16 bushels. The details are given in the accompanying table.

Yield of cereals in Europe.

Year.	Wheat.	Rye.	Barley.	Oats.	Year.	Wheat.	Rye.	Barley.	Oats.
	Bushels.	*Bushels.*	*Bushels.*	*Bushels.*		*Bushels.*	*Bushels.*	*Bushels.*	*Bushels.*
1876-1880	12.90	11.84	17.88	24.08	1891-1895	14.10	13.28	19.76	26.32
1881-1885	13.65	12.16	18.43	24.36	1896-1900	13.95	14.08	18.62	27.16
1886-1890	13.50	12.48	18.62	25.20	1901-1904	15.00	....	....	....

The records of Denmark, Holland, Belgium, Norway, Austria, and other European countries for which data are available show continued increase in the yield per acre of cereal crops, as in the cases cited above.

From this historical evidence it appears that on these old soils of the old countries, which have been under cultivation for a thousand years, the yields within the last century have actually increased, as shown not only by general statistics gathered by the States, but by the statistics of individual farms which have been continually under the management and in the possession of the same families. This shows that, so far from wearing out, these soils have been steadily increasing in productivity within the period of which we have statistical records. This increase is due to better methods of cultivation, more systematic rotation of crops, more care in the selection of seed, increase of live stock, and in later years to the introduction of commercial fertilizers—guano from Peru, nitrate from Chile, phosphate from the United States, potash from Germany; but how much is due to each of these factors can not be determined by any available records.

FERTILITY OF SOILS CAN BE TEMPORARILY IMPAIRED.

While in the foregoing it has been shown that soils do not wear out in the sense that we have been accustomed to use this term and that there is no general deterioration of lands, the individual can abuse his soil as he can abuse his own physical powers, but in the long run, even in the finite time with which we are concerned, it does not affect the great problem of the general fertility of the soil. It is but a detail making up the general average of national soil conditions.

The fertility of the farm can be temporarily impaired by improper or careless cultivation, as in the case of cotton soils of the South, where erosion is so rapid that we can hardly maintain from year to year the soils that we last year cultivated. And what becomes of the soil that is eroded? It forms the fertile rice lands of the deltas of the rivers. These are the soils from the poor washed lands of the up-country changed as to their organic matter content, which they have acquired in their gradual progress down the streams, and changed as a result of this organic content in their physical properties, but unchanged with respect to the kind of minerals they contain. They are not and never have been exhausted of plant food. With this change of state they are wonderfully productive.

The fertility of the soils can also be temporarily impaired by improper rotation of crops as has already been shown.

A recent bulletin (No. 96) of the South Dakota Experiment Station reports a very interesting experiment bearing upon this point, not only as regards the possibility of impairment but the ease with which the crop-producing power of the soil can be temporarily impaired.

The character of the soil and the lay of the land is somewhat poorer than the average in Hyde County. 1903 was a good year for nearly all crops. 1904 was favorable to the maturity of early crops and small grains, but the late drought destroyed most all of the later crops. * * * In 1903 three pieces of land, each 8 rods wide, lying side by side and separated only by roads 1 rod wide, were cropped as follows: One was in wheat, the second was in corn, and the third was summer fallowed. Previously to 1903 all had about the same treatment.

	After wheat.	After corn.	After fallow.
Wheat	2.7	17.8	9.3
Emmer	3	36.9	32.2
Barley	0	23.3	17.5
Oats	1.4	48.1	54.4

* * * The season of 1904 at Highmore was very dry, the rainfall for the five growing months being 8.55 inches.

* * * As a result of the dry weather, everything was a total failure on the land that had grown a crop of small grain the year before.

* * * On the land that had been in corn the year before, separated from the latter plats only by a road a rod wide, sown with the same drill, the same seed, and at the same time, we harvested a reasonably good crop of all kinds of grain.

* * * On the summer-fallowed land lying next to the corn ground and with all conditions the same except the preparation of the land, the crop was

fairly good, but with the exception of the two varieties of oats was not as good as on the corn ground.

* * * All our experience goes to prove that as good a crop of grain can be grown following a well-tended crop of corn as can be grown after the best summer fallow. In fact, we have some very strong evidence now to prove that the fertility and crop-producing powers of the soil are maintained longer by a system of alternate cropping to corn than they are by a system of summer fallowing.

* * * This instance of small grain being a total failure when grown after small grain in a dry year, while at the same time a good crop was produced after corn is not an isolated case, but it is the general rule. In fact, it is becoming so well known that in some sections of both this and other States with similar climatic conditions farmers make a practice of planting half their land to corn or some other cultivated crop every year, and never think of sowing small grain after small grain. It is the introduction of such practices as this, with their attendant good results, together with the introduction of varieties of grain adapted to the conditions of soil and climate that lends color to the more or less general belief that the climate is undergoing a permanent change.

They find, therefore, that grain does materially injure the soil for grain again, that corn appears to improve it, even over summer fallow, and yet during the fallow no plant food is removed, while with the crop of corn certainly a considerable amount of plant food is removed, notwithstanding which the soil is left in better condition for the following crop. Whether this was due to moisture conditions, the presence of toxic substances, or other causes, the results bring out very strikingly the effects of different methods in improving the crop-producing power of the soil.

To these very striking illustrations could be added any amount of evidence of the deterioration of fields in almost any community. Lands normally producing from 40 to 60 bushels of corn per acre if turned over to tenant farmers are liable to become very unproductive in a short time. They take on the appearance that we attribute to worn-out and exhausted soils, but surely their present condition is not due to the loss of plant food, since by the gradual "exhaustion" by poor farming these lands have constantly produced less than the better farmed fields. In such cases it is well known that these lands could easily be brought up to produce fair crops by better methods of cultivation.

The great point to be made here is that our judgment is apt to be influenced by these individual cases of the temporary impairment of the productive power of the soil and that statistics fail to show that there is any widespread exhaustion or deterioration of the soil.

As we see it now, the main cause of infertile soils or the deterioration of soils is the improper sanitary conditions originally present in the soil or arising from our injudicious culture and rotation of crops. It is, of course, exceedingly difficult to work out the principles which govern the proper rotation for any particular soil.

The important thing is that we now understand the nature of the soil; how it supplies the nutrient constituents for the crops and how it maintains this supply; how crops may affect each other when grown in succession on the soil; how cultivation affects the conditions resulting from the crop, and, lastly, we are beginning to understand how fertilizers come into this scheme and themselves act on or change toxic conditions in the soil, rendering the soil again sweet and healthy for the growing crop.

It has been shown that our impressions of the deterioration of the wheat soils of the Northwest are apparently incorrect. These impressions have probably been derived from exceptionally high yields on certain farms and from recollections of individuals, frequently recorded in newspaper articles. As a matter of fact, the soils as a whole are actually producing more now with the introduction of better methods than they formerly did. For analogy reference has been made to the impressions which are prevalent in regard to a change in the climate.

It has been shown that on abandoned farms in certain areas in the New England States and in New York the actual yield per acre is as great now as it was formerly, and that the cause of the abandonment of the farms must be sought in other lines than the exhaustion of plant food from the soils.

It has been shown that in southern Maryland and in middle Virginia the cause of the recent depression in agriculture and of the low yield of crops is due to methods which have prevailed rather than to any exhaustion of the soil, and that with improved methods these areas are coming up and will again be made to produce satisfactory crops. The soils are not wearing out in the sense that they are unable longer to provide mineral nutrients, but the yields are low because through the prevailing methods the soils have not been maintained in proper condition. In these latter instances the yields have actually declined, but not from the cause which has been generally ascribed.

It has been shown that from the modern conception of the nature and purpose of the soil it is evident that it can not wear out, that so far as the mineral food is concerned it will continue automatically to supply adequate quantities of the mineral plant foods for crops, but it has also been shown that the soil can be abused and its fertility temporarily impaired by improper methods of handling.

Lastly, it has been shown from the statistics of European countries that the soils of the world are not wearing out, but that, on the contrary, after a thousand years of cultivation, with the introduction of better methods, with the necessity of raising larger crops, these soils are responding with an increased yield even over what they produced at the beginning of the last century.

58055—Bull. 55—09——6

As a national asset the soil is safe as a means of feeding mankind for untold ages to come. So far as our investigations show, the soil will not be exhausted of any one or all of its mineral plant food constituents. If the coal and iron give out, as it is predicted they will before long, the soil can be depended upon to furnish food, light, heat, and habitation not only for the present population but for an enormously larger population than the world has at present.

Personally, I take a most hopeful view of the situation as respects the soil resources of our country and of the world at large. I can not bring myself to believe that the discouraging reports that have been issued from time to time as to the threatened deterioration of our soils, as to the exhaustion of any particular element of fertility, will ever be realized. While I know that soils do change in the infinite order of time, I have no thought that they do change materially, structurally, profoundly, in the finite range of human experience or of human knowledge. It is dependent upon us to study the soil to understand the changes brought about by cultivation and by cropping, to win from the soil not only our present yields, but increasing yields for the larger population that we can reasonably expect.

It must not be assumed that even if these commonly accepted impressions regarding the deterioration of soils through loss of plant food are wrong, that there is no field for soil investigation. The question is just now assuming the importance of a science. We are just beginning to realize the nature of the soil, its functions, and its relations to crops. There are certain great problems that will have to be worked out under government auspices. These questions are too far-reaching, too profound, too universal, for any one person or any local institution to solve. The laws governing the soil and its relation to crops, including the rotation of crops, have to be better understood. Upon what principles are they based? What does the plant do to the soil? What do bacteria do to the products of the plant? How can these agencies be aided or controlled for the good of mankind? Why does not the soil purify itself and keep itself in condition to destroy the waste products of the plant? It ought to do so. It is intended that it should and in the best soils it does.

We will have to understand better than we do now the necessary physical treatment of soils through methods of cultivation—what cultivation does, how it improves the texture or the sanitary conditions of the soil. We know that the soil needs stirring; it needs change. Just how does this operate to improve the condition of the soil for the coming crop? The way fertilizers act, and when and under what conditions they are necessary, and how most effective, are questions which must be better understood than they are at present.

PART II. CLASSIFICATION AND DISTRIBUTION OF THE SOILS OF THE UNITED STATES.

INTRODUCTION.

The soil is the greatest natural resource of the Nation. With the exhaustion of coal and iron it will supply, if rightly used, not only food and clothing as at present, but also fuel, light, power, and structural materials now supplied to a greater or less extent by these minerals. It produces now over $7,000,000,000 in products annually, forming the basis of our industrial wealth and a large proportion of our foreign exports, yet we are but now taking up the last of our public lands available for cultivation and the country is still so sparsely settled that only about a quarter of the land nominally in farms is actually under cultivation.

From these lands we are getting only a third or a half the yield per acre obtained on the older soils of Europe, and within the past fifty years we have seen in many individual farms the productivity of our new soils decline more than in equal proportion to the increase in productivity of European countries. The population of the country is rapidly increasing and the time has surely come when we must face the situation and when we should take an account of stock and deliberate as to what should be done to increase the returns from the land and yet leave the soil in better condition for succeeding generations. The soil is the one natural resource which, if properly used, not only clothes and feeds us, but improves with age and careful treatment for the continued use of posterity. What these soil resources are the Bureau of Soils is determining through the soil survey. How they should be utilized the department, through its several bureaus and the experiment stations, is learning. But under all, as a basis of all intelligent development, is the knowledge of and classification of the soils.

Few realize the frequent changes of location made by the American farmer and farm laborer. It is not with us as it is in most of the European countries, where families live for generations on the same land until they get from long experience and by force of circumstances and necessity an intimate knowledge of its peculiarities and of the best ways to handle it, although they may pretend to little knowledge of other soils of different texture or other peculiarities. One method of cropping or of soil management can not succeed equally on all our soils, nor can any text-book show all the methods or all the agencies for the improvement of our different soils, but enough is now known about the cause of fertility and infertility for the public to understand that an impoverished or run-down soil is due to extreme poverty of the owner or tenant, to neglect or to actual abuse, as we realize now that these factors form the principal causes of the occurrence and spread of many contagious, infectious, or epidemic diseases.

The Bureau of Soils on January 1, 1908, completed the detailed soil mapping, on the scale of 1 inch to the mile, of areas amounting to 146,606 square miles, or 93,828,114 acres, in continental United States. This work has been widely distributed in 300 areas, usually of county units, in all of the States and Territories except Maine and Nevada. The areas have been selected with some reference to the density of population, and with particular regard to the different agricultural districts and agricultural interests of the country. Comparing this area with the area of certain foreign countries, it will be seen that it is larger than Great Britain (including England, Scotland, Ireland, and Wales), three-fourths the size of France, larger than Italy, and about the size of Japan, but much less thickly populated, as appears from the following table:

Area and population of the United States and of certain foreign countries.

Country.	Area.	Population.	Population per square mile.
	Sq. miles.		
German Empire	208,780	60,641,278	290
France	207,054	38,961,945	188
Spain	194,783	18,618,086	96
Japan	147,655	46,732,138	316
United States (surveyed)	146,606	[a] 6,000,000	41
Great Britain and Ireland	121,391	41,976,827	346
Equador	116,000	1,205,600	10
Italy	110,550	32,475,253	294
Paraguay	98,000	631,347	6
Portugal	35,490	5,423,132	153
Greece	25,014	2,433,806	97
Switzerland	15,976	3,463,609	217
Denmark	15,592	2,605,268	167
Netherlands	12,648	5,591,701	442
Belgium	11,373	6,693,548	589

[a] Estimated.

The amount of work done in each State and the actual cost of the field work, including salaries and field expenses of the men, are given in the accompanying table.

Soil surveys to January 1, 1908.

State or Territory.	Area.	Total cost.	State or Territory.	Area.	Total cost.
	Sq. mi.			*Sq. mi.*	
Alabama	9,746	$26,828	Nevada		
Arizona	859	4,602	New Hampshire	923	$2,126
Arkansas	2,678	7,512	New Jersey	1,279	2,477
California	7,552	36,399	New Mexico	128	1,200
Colorado	2,428	8,307	New York	5,597	14,176
Connecticut	506	936	North Carolina	7,727	17,243
Delaware	314	498	North Dakota	4,552	11,208
Florida	2,955	9,876	Ohio	4,144	7,567
Georgia	2,423	5,884	Oklahoma	1,163	3,213
Idaho	1,281	2,124	Oregon	442	1,355
Illinois	5,951	8,634	Pennsylvania	3,744	10,364
Indiana	3,544	7,365	Rhode Island	1,084	1,654
Iowa	2,271	3,055	South Carolina	6,348	15,010
Kansas	3,180	6,784	South Dakota	674	985
Kentucky	2,079	3,982	Tennessee	4,740	9,204
Louisiana	5,775	16,487	Texas	12,428	33,822
Maine			Utah	1,501	6,608
Maryland	3,605	6,450	Vermont	227	528
Massachusetts	809	1,511	Virginia	5,916	13,674
Michigan	3,789	8,307	Washington	1,651	4,976
Minnesota	2,144	5,155	West Virginia	1,615	4,268
Mississippi	5,340	16,810	Wisconsin	2,593	5,479
Missouri	5,045	7,993	Wyoming	309	1,070
Montana	432	1,900			
Nebraska	3,115	5,980	Total	146,606	371,586

This wide distribution of the work, besides benefiting the people in a somewhat equitable way in each of the States, has enabled the Bureau to acquire in the shortest possible time and with the least expenditure of funds a knowledge of the soils of the entire country that could not have been obtained in any other manner. With the information now available it has been possible to construct a general map of the United States, showing the great soil provinces, although not sufficient work has been done to construct a detailed soil map of any one of these provinces. The following table gives the name and area of the soil provinces and the proportion of each that has been covered by the soil survey. It is not unlikely that as the work progresses and as our knowledge of the soils increases it will seem advisable to divide some of these provinces into two or more parts.

Soil provinces of the United States.

Province.	Estimated area.	Area surveyed.	
	Acres.	*Acres.*	*Per cent.*
Atlantic and Gulf coastal plains	233,000,000	25,613,666	10
River flood plains	64,000,000	8,061,247	13
Piedmont Plateau	48,000,000	7,271,798	15
Appalachian Mountains and plateaus	72,000,000	6,367,009	9
Limestone valleys and uplands	68,000,000	6,052,926	9
Glacial and loessial	455,000,000	22,417,832	5
Glacial lake and river terraces	41,000,000	5,091,882	12
Residual soils of western prairie	107,000,000	1,825,850	2
Great Basin	109,000,000	1,005,600	1
Northwestern intermountain region	76,000,000	1,455,428	2
Rocky Mountain valleys and plains	365,000,000	2,939,840	1
Arid Southwest	58,000,000	1,131,155	2
Pacific coast	21,000,000	4,593,881	22
Western mountain regions	211,000,000		
Total	1,928,000,000	93,828,114	

It is estimated that the areas which have been surveyed contain a rural population [a] of about 6,000,000 people, or about one-sixth of the rural population of continental United States. It is estimated that with the Congressional distribution and the requests which have come to the Department upward of 1,500,000 copies of the soil maps and accompanying reports have been distributed, not only to people within the areas surveyed, but to a large number of people seeking information regarding the soil resources of these areas.

It is proposed now to give a succinct statement of the knowledge that has been acquired of the soils and the soil resources of the United States. No attempt will be made to give a detailed description of the 715 soil types so far encountered and only a very brief description of the 86 soil series which have been established, as this information is given in detail in the separate reports on the different areas and in a more technical way in the Soil Survey Field Book, which can be consulted in most of the public libraries or can be obtained directly from the Department. It is intended briefly to set forth the agricultural value of the several types of soil, or the way in which they are at present being used, mentioning for this purpose, however, only the principal crops or agricultural interests and not going into a detailed statement of all the crops which are grown or into methods of cultivation or soil management. Such a detailed treatment of the soils of the United States would far exceed the limits of this publication and can well be deferred until the soils of the several provinces are written up in detail.

BRIEF DESCRIPTION OF THE SOIL SERIES.

The following very brief description of the soil series which have been established in the United States, arranged under the soil provinces in which they occur, will be found useful as a key to the more detailed descriptions of the soil types which follow:

ATLANTIC AND GULF COASTAL PLAINS.

Bastrop series.—Brown soils with reddish-brown to red subsoils occurring as nonoverflow terraces. Cotton, corn, sorghum, alfalfa, melons, and potatoes are successfully produced.

Crockett series.—Dark-gray prairie soils underlain by mottled red subsoils. Derived from slightly calcareous material, the soils of this series are productive. Cotton and the general farm crops are the leading products. The gravelly soil is early and adapted to early truck.

---

[a] Cities of more than 25,000 inhabitants have been excluded.

Elkton series.—Light-gray to white surface soils, with mottled whitish gray and yellow subsoils, overlying gravel and coarse sands.

Gadsden series.—Gray soils, with subsoils of similar texture occupying gentle slopes and depressions and formed by wash or creep from higher areas. This series occurs in rather local development, particularly in Florida, southern Georgia, and Alabama. They are very productive soils and well adapted to tobacco. No heavy members of the series have been encountered, and it is doubtful if any exist.

Guin series.—Gray soils with brown to yellowish-red subsoils, occurring as rolling and hilly uplands. Intermediate series between the Norfolk and Orangeburg series. Owing to the rather rough topography these soils have not been developed as much as either of the other series, although they seem capable of producing better crops than they do now.

Houston series.—Dark-gray or black calcareous prairies. One of the most productive series for Upland cotton and well adapted to alfalfa and other forage crops.

Laredo series.—Gray to light-brown calcareous soils with gray subsoils. Good cotton, corn, and sugar cane soils, and especially adapted to the early production of vegetables—cabbage and onions in particular.

Lufkin series.—Light-colored soils with heavy mottled gray and yellow subsoils. The soils of this series have only a moderate degree of productivity.

Montrose series.—Gray soils with heavy plastic mottled yellow subsoils. These soils are in part poorly drained, but where cultivable they produce moderate yields of cotton and corn.

Myatt series.—Gray soils with mottled yellow, gray, and whitish subsoils occurring in poorly drained areas around heads of streams and intermediate between uplands and bottom lands. This series seems to be of local extent and but little developed.

Norfolk series.—Light-colored soils with yellow sand or sandy clay subsoils. This series contains some of the most valuable truck soils of the Atlantic and Gulf Coast States, and certain members of the series are adapted under certain climatic conditions to wheat, grass, tobacco, and fruit.

Oktibbeha series.—Gray soils with brown to yellowish-brown heavy subsoils related to Houston series in origin. The soils of this series are distinctly inferior to the soils of the Houston series and, as they appear to cover large areas in Mississippi and Alabama, present a difficult problem in soil improvement.

Orangeburg series.—Light-colored soils with red sandy clay subsoils. This series constitutes some of the best cotton soils of the

South, and certain members of the series are particularly adapted to tobacco.

Portsmouth series.—Dark-colored soils with yellow or mottled gray sand or sandy clay subsoils. Where drainage is adequate this series is adapted to some of the heavier truck crops, to small fruits, and to indian corn.

Sassafras series.—Yellowish-brown surface soils with reddish-yellow to light-orange subsoils overlying gravel beds.

Susquehanna series.—Gray soils with heavy red clay subsoils which become mottled and variegated in color in the deep subsoil. Only one member of this series, the sandy loam, has been developed to any considerable extent. This one is used for fruit and general farm purposes, but the other members are particularly refractory and difficult to bring into a productive state.

Webb series.—Brown to reddish-brown soils with reddish-brown to red subsoils, a semiarid prototype of the Orangeburg series. The soils of this series have not been used to any great extent, owing to lack of irrigation facilities.

Wickham series.—Reddish or reddish-brown terrace soils overlying reddish, micaceous heavy sandy loam or loam subsoils. The soils of this series have a relatively high productivity for general farm crops.

Wilson series.—Dark-gray prairie soils with mottled gray subsoils. The clay member of this series is a strong soil devoted to general farming, with cotton as the leading crop. The other members are used for cotton, but are inclined to be droughty.

RIVER FLOOD PLAINS.

Congaree series.—Brown or reddish-brown soils found along Piedmont streams and representing wash from Cecil soils. Valuable and dependable corn soils, but too low and moist for cotton.

Huntington series.—Dark-brown to yellowish-brown soils occurring along streams in the Allegheny plateaus. Both the general farm crops and truck crops thrive on these soils.

Miller series.—Brown to red alluvial soils formed from the reworking of materials derived from the Permian Red Beds. Very productive soils suitable for cotton, corn, sugar cane, alfalfa, and vegetables; especially adapted to peaches.

Ocklocknee series.—Gray to yellowish-brown soils found along streams in Coastal Plain Georgia, Alabama, and Mississippi. Cotton, corn, and pasturage are the leading products.

Wabash series.—Dark-brown or black soils subject to overflow. Very productive soils used for cotton, sugar cane, corn, wheat, oats, grass, alfalfa, sugar beets, and potatoes and other vegetables.

Waverly series.—Light-colored, alluvial soils subject to overflow. Less productive than the Wabash soils, but adapted to the same wide range of crops.

Wheeling series.—Brown to yellowish-brown soils occurring on gravel terraces along streams issuing from glaciated regions. Excellent soils for general farming, and fruit and truck growing.

PIEDMONT PLATEAU.

Cecil series.—Gray to red soils with bright-red clay subsoils, derived from igneous and metamorphic rocks. Constituting by far the larger portion of the province, these soils are well adapted to and used for cotton, export tobacco, and fruit, and the lighter members for truck crops. As a rule they are not highly developed, but where properly handled the heavier members produce excellent crops of corn and grazing and hay grasses.

Chester series.—Gray to brown surface soils with yellow subsoils, derived principally from schists and gneisses. The most valuable soils of the province for wheat and corn and good for certain fruits. The most highly developed soils of the Piedmont plateau.

Penn series.—Dark Indian-red soils with red subsoils, derived from red sandstones and shales of Triassic age. Excellent soils for general farm crops, particularly wheat, corn, and hay.

APPALACHIAN MOUNTAINS AND PLATEAU.

Dekalb series.—Brown to yellow soils with yellow subsoils, derived from sandstones and shales. Soils of this series are used, according to texture, elevation, exposure, and character of surface, either for the production of hay, for pasture, or for orchard and small fruits.

Fayetteville series.—Grayish-brown to brown soils with yellowish or reddish-brown subsoils. Adapted to apples, grapes, and small fruits, and give moderate yields of general farm crops.

Porters series.—Gray to red soils with red clay subsoils, derived from igneous and metamorphic rocks. This is the greatest mountain fruit series of the eastern United States. It is also used for general farming.

Upshur series.—Brown to red soils with red subsoils, derived from sandstones and shales. Somewhat more productive than the Dekalb soils. Used for cotton, corn, wheat, and forage crops.

LIMESTONE VALLEYS AND UPLANDS.

Clarksville series.—Light-gray to brown soils with yellow to red subsoils, derived mainly from the St. Louis limestone. While not as strong as the Hagerstown soils, this is a valuable series. Apples and peaches are commercially important. Tobacco is a leading product. General farming is firmly established in many extensive regions.

Cumberland series.—Brown surface soils, derived from thin deposit of sedimentary material overlying residual limestone subsoils. Used for cotton and other general farm crops, truck, and fruit.

Decatur series.—Reddish-brown to red soils with intensely red subsoils. Intermediate in value between the two series just described. Cotton, corn, wheat, oats, forage crops, bluegrass, and peaches are the leading crops.

Hagerstown series.—Brown to yellowish soils with yellow to reddish subsoils, derived from massive limestone. Among the most productive soils of the eastern United States. Fine wheat and general farming soils, and the seat of important apple orcharding interests. Bluegrass is indigenous.

GLACIAL AND LOESSIAL REGIONS.

Marshall series.—Dark-colored upland prairie soils. The principal soils of the great corn belt belong to this series, while in the Northwest the finest wheat soils are found in this group. They are among the best general farming soils of the entire country.

Miami series.—Light-colored upland timbered soils. The different members of this series are considered good general farming soils and have in addition special adaptations for truck, fruit, small fruit, and alfalfa.

Volusia series.—Light-colored soils with yellowish subsoils, derived by feeble glacial action from sandstones and shales. The soils of this series are adapted to the production of potatoes, grass, oats, buckwheat, and in the less elevated positions to corn.

GLACIAL LAKE AND RIVER TERRACES.

Clyde series.—Dark-colored swamp soils formed from reworked glacial material deposited in glacial lakes. A special use for these soils is the production of sugar beets, while general farm crops, truck, and canning crops are grown extensively.

Dunkirk series.—Light-colored reworked glacial material occurring as terraces around lakes and along streams. Good general farming soils and especially adapted to grapes and other fruits.

Fargo series.—Black calcareous soils rich in organic matter formed by deposition of material in glacial lakes. This is the most important group of soils in the Red River Valley, and includes exceptional soils for the production of wheat, barley, and flax. While these are the chief crops at present, the soil adaptations are by no means limited to small grain production. Timothy and vegetables may become more important products with the development of markets.

Hudson series.—Light-brown to yellowish-brown soils, with drab to yellowish subsoils.

Merrimac series.—Brown terrace soils underlain by gravel formed principally of reworked glaciated crystalline rocks. Leachy soils of low general farming value, but especially adapted to trucking and apple orcharding in some sections.

Sioux series.—Dark-colored soils resting on dark or light-colored subsoils, with gravel beds usually within 3 feet of the surface. The crops produced on soils of this series range from early short-seasoned truck crops through special crops like alfalfa and sugar beets to the wide variety of general farm crops produced in the Central West.

Superior series.—Gray and red soils with red subsoils, formed from reworked glacial material deposited in glacial lakes. Not extensively developed, but known to include fine types for clover, timothy, and small fruits.

Vergennes series.—Light-colored soils, with gray or whitish subsoils, derived from Champlain clays or lighter deposits over these clays. This series includes the best hay and apple soils of the Champlain Valley. A wide variety of tillage crops is grown, but cultivation of the heavier members of the series is very difficult.

RESIDUAL SOILS OF THE WESTERN PRAIRIE REGION.

Crawford series.—Brown soils with reddish subsoils, derived from limestones. The soils of this series range from rough areas suited mainly for pastures to fertile general-farming, fruit-growing, and trucking soils.

Oswego series.—Gray or brown soils, derived from sandstones and shales. The lighter members of this series are adapted to corn, oats, potatoes, truck, and fruit; the heavier to these crops and wheat.

Vernon series.—Brown to red soils typical of the Permian formation. Soils of this series show a wide adaptation according to texture. General farm crops, including cotton, corn, wheat, Kafir corn, and sorghum are the leading products. Small fruit, peaches, and truck are grown to some extent and are capable of marked extension.

GREAT BASIN.

Bingham series.—Porous dark or drab colluvial and alluvial soils underlain by gravel or rock, occupying lower mountain slopes. The lighter types when irrigable are devoted to orchard fruits, the heavier types to alfalfa and sugar beets.

Jordan series.—Light to dark-colored lacustrine deposits. These soils are utilized principally in the production of alfalfa, sugar beets, truck crops, and grains under favorable conditions for irrigation and drainage, but considerable areas covered by some of the members of this series are not utilized on account of the accumulation of alkali, poor drainage, or because of their drifting character.

Malade series.—Dark-colored alluvial soils underlain by light-colored sands, sandy loams, or heavy reddish material. These soils are devoted chiefly to sugar beets, alfalfa, grain, and some orchard fruits.

Redfield series.—Red soils consisting of colluvial and alluvial materials derived from red sandstones and other rocks. The lighter members are adapted to the production of alfalfa, grain, and general farm crops when irrigable and well drained. The heavier members, as far as encountered, are poorly drained and have not been developed.

Salt Lake series.—Dark-colored soils underlain by stratified sediments of lacustrine origin. These soils, as far as encountered, occupy very low, flat positions around the lake and have not been developed to any extent.

NORTHWESTERN INTERMOUNTAIN REGION.

Bridger series.—Dark-colored soils with sticky yellow subsoils, of colluvial and alluvial origin. These soils generally occupy elevated foot slopes or sloping valley plains and have not been developed to a great extent. They are most extensively used for the production of grain and when irrigated are utilized in the production of alfalfa and other hay crops and under favorable climatic conditions are adapted to fruits.

Gallatin series.—Light to dark-colored soils with yellowish to dark compact subsoils, of recent alluvial origin from basaltic and volcanic rocks. These soils generally occupy low positions, very frequently poorly drained, often subject to overflow, and have not been extensively developed for agricultural purposes. They are used chiefly for grazing and to some extent in the production of hay, grains, and in some sections for vegetables.

Yakima series.—Ash-gray to light-brown soils derived principally from ancient lake sediments consisting of an admixture of volcanic dust and basaltic, andesitic, and granitic materials. Certain members of this series have been very successfully developed for hop culture, alfalfa, grass, grain, and fruit, while other members of the series, owing to their elevated position and general rough character, have not been developed at all.

ROCKY MOUNTAIN VALLEYS, PLATEAUS, AND PLAINS.

Billings series.—Compact adobelike gray to dark or brown soils and subsoils, formed mainly by reworking of sandstones and shales and occupying old elevated stream terraces. This is an important series adapted to alfalfa and general farm crops and stock raising; also used to a considerable extent in the production of sugar beets.

Colorado series.—Light-gray to reddish-brown soils and subsoils, derived from colluvial wash. Where irrigable these soils are important soils in the production of alfalfa, sugar beets, melons, and to a limited extent, fruits. A number of the soils of the series, however, are so situated as not to be susceptible to irrigation, and have not been developed for agricultural purposes.

Finney series.—Brown to nearly black soils derived from glacial material underlain by lighter colored subsoils. The heavier soils may be dry farmed to advantage and would become very productive with irrigation. The lighter soils have a broken surface, are porous and easily drifted by the wind. They are best adapted to grazing.

Fruita series.—Reddish-brown soils, formed by reworking of sandstones and shales, occurring as stream terraces. When well drained and free from alkali the members of this series are admirably adapted to the production of choice fruits, alfalfa, sugar beets, grains, and truck crops.

Laramie series.—Dark-colored soils, with light-colored gravelly subsoils, derived from colluvial mountain wash. These soils have not been extensively developed owing to their elevation, and are used principally for grazing purposes.

Laurel series.—Light-gray to black soils, underlain by river sands or gravels, occurring in flood plains along streams. Under favorable moisture conditions these are fertile soils, adapted according to locality to corn, alfalfa, sugar beets, and truck crops, but the areas are often subject to overflow, and in some cases can not be drained.

Mesa series.—Light-gray to brown soils derived from old flood-plain deposits, now elevated to form mesa lands. Where these soils have been developed and are susceptible of irrigation they are used mainly for alfalfa and sugar beets. One member of the series has been quite extensively and very successfully used for the production of apples and peaches.

Morton series.—Brown residual soils, derived from sandstones and shales. The soils lie in the semiarid region, and give good yields of wheat, flax, oats, and potatoes when rainfall is sufficient.

San Luis series.—Reddish-brown gravelly soils, formed from lacustrine sediments of volcanic rock materials. On account of the position and the danger from alkali these soils have not been successfully developed, but have been used mainly for pasturage and forage crops.

Wade series.—Brown to dark-brown alluvial soils, formed by reworking of sandstones and shales. Used for oats, flax, millet, and wheat.

ARID SOUTHWEST.

Gila series.—Light to dark brown soils of flood-plain alluvium underlain at varying depths by coarse sands and gravels. Under favorable irrigation and drainage conditions the members of the Gila series are adapted chiefly to the production of alfalfa, potatoes, truck, and root crops.

Imperial series.—Light-colored or reddish soils formed from old marine or lacustrine sediments modified by more recent deposits and underlain to great depths by heavy material. These soils are particularly adapted to alfalfa, sorghum, and other forage crops.

Indio series.—Light-colored soils usually underlain by coarser sands and gravels, formed by colluvial and alluvial wash from granitic rocks, mingled with some shale and sandstone. These soils are adapted to fruit, truck crops, sweet potatoes, melons, and alfalfa under favorable conditions of irrigation and drainage.

PACIFIC COAST.

Anderson series.—Reddish-gray or light-red alluvial soils occupying principal valley plains and the bottoms of intermittent streams. Generally gravelly. The soils of this series when not too gravelly are adapted to the production of peaches, pears, prunes, and small fruits, but are, in so far as mapped at present, inextensive types of secondary agricultural importance.

Fresno series.—Light-colored soils with light-gray, ashy subsoils and alkali-carbonate hardpan, derived from old alluvial wash. Where protected from alkali accumulations these soils have been very successfully used for vineyards and raisin grapes, and are particularly adapted to almonds, peaches, and apricots.

Hanford series.—Recent alluvium of flood or delta plains derived from a variety of rocks. The light-textured soils are light in color and the heavy-textured soils are dark in color. The lighter members of the series are adapted to the same class of fruits and raisin grapes as the Fresno series. The heavier members of this series, however, are better adapted to alfalfa, sugar beets, celery, asparagus, and other truck crops.

Maricopa series.—Loose, dark-colored soils derived from unassorted colluvial or partially assorted alluvial materials, generally derived from granitic or volcanic rocks. There are two heavy members of this series upon which alfalfa, grain, and sugar beets are important crops. The lighter members, when occupying positions so that they can be irrigated, are adapted to citrus and deciduous fruits; also vines.

Oxnard series.—Dark-colored alluvial or colluvial soils derived from higher lying areas of sandstones and shales. Members of this series are used to a very large extent for sugar beets and lima beans, and, where irrigation is not practicable, extensively used for grain.

Placentia series.—Reddish soils derived largely from the weathering of alluvial and colluvial deposits, generally underlain by heavy compact red material with an impervious adobe structure. Large areas of these soils are devoted to dry farming of grain and occur throughout southern California and in some of the coastal valleys, viz, Bakersfield, Salinas, and San Jose. There are extensive areas under irrigation, which are valuable for producing both deciduous and citrus fruits. The heavier members of this series have been more successfully used for grain production in southern California. They seem particularly well adapted to English walnuts and olives. The soils are usually well drained. The English walnut does not thrive on poorly drained soils.

Redding series.—Ancient alluvial valley deposits of red and deep-red color, generally gravelly. Heavy red subsoils with hardpan. The soils of this series when not carrying an excess of cobbles or underlain at shallow depths by hardpan are excellently adapted to the production of choice peaches and small fruits.

Sacramento series.—Gray alluvial soils consisting of recent stream sediments. The lighter members of this series are used mainly for the production of prunes, pears, and peaches. The members of the series having a medium texture are adapted to sugar beets, alfalfa, and prunes. The heavier members are at present poorly drained and have not been highly developed, being used mostly for grain and grazing.

Salem series.—Residual, alluvial, or colluvial soils, either red or dark in color, derived from rocks of basaltic, schistose, crystalline, or arenaceous character. These soils, so far as they have been encountered, seem particularly adapted to hops, potatoes, and have been used to some extent for apples, peaches, and grain. They have not been very highly developed in the areas in which they have been encountered.

San Joaquin series.—Compact red soils and subsoils derived from old marine sediments, usually underlain by red hardpan. These soils have been used almost exclusively for dry farming to grain on account of the general occurrence of hardpan and very stiff and impervious subsoils. Recently in the Sacramento area some members of this series have been very successfully used for the production of the Tokay grape and strawberries.

Sierra series.—Light-gray to red and frequently gravelly soils, often underlain by red adobe. Members of this series constitute some of the most valuable deciduous fruit soils of the foothills in northern California.

Sites series.—Residual and colluvial soils of reddish-gray or dark-brown color, derived from sandstones, shales, conglomerates, and volcanic or altered material occupying low rolling foothills and their valley slopes, usually underlain at shallow depths by sandstones, congomerates, or heavy subsoils. The Sites loam and clay loam adobe are the important soils of this series and are productive, but owing to their position are generally unirrigable and adapted to dry farming to grains.

Stockton series.—Brown to black soils with heavy yellow subsoils, derived from old alluvial sediments. These soils have been used principally for the production of grain. The lighter members of this series have been adapted to fruit.

Willows series.—Brown soils consisting of wash deposited by intermittent foothill streams. These soils have been used almost exclusively for dry farming grain crops. Large ranches are being broken up and brought under irrigation, and alfalfa and sugar beets are likely to prove the most important crops.

Area of the soil series and the combined area of the miscellaneous soils of each of the provinces.

Province and series.	Acres.
Atlantic and Gulf Coastal Plains:	
Norfolk series	9,612,882
Orangeburg series	3,486,464
Houston series	2,326,016
Portsmouth series	1,729,160
Susquehanna series	1,495,990
Lufkin series	1,375,808
Sassafras series	497,344
Guin series	455,104
Elkton series	184,852
Webb series	184,512
Wilson series	175,040
Myatt series	86,912
Gadsden series	78,528
Oktibbeha series	72,448
Montrose series	64,768
Bastrop series	58,432
Laredo series	55,040
Crockett series	29,504
Wickham series	17,664
Miscellaneous soils	3,627,198
Total for province	25,613,666
River flood plains:	
Wabash series	1,861,497
Waverly series	882,240
Miller series	595,904
Huntington series	258,496
Ocklocknee series	236,416
Congaree series	183,232
Wheeling series	20,032
Miscellaneous soils	4,023,430
Total for province	8,061,247
Piedmont Plateau:	
Cecil series	5,191,746
Penn series	726,364
Chester series	692,698
Miscellaneous soils	660,990
Total for province	7,271,798
Appalachian mountains and plateau:	
Dekalb series	2,864,320
Porters series	1,664,528
Fayetteville series	179,968
Upshur series	163,904
Miscellaneous soils	1,494,289
Total for province	6,367,009
Limestone valleys and uplands:	
Clarksville series	3,623,322
Hagerstown series	1,889,884
Limestone valleys and uplands—Continued.	
Decatur series	190,464
Cumberland series	69,376
Miscellaneous soils	279,880
Total for province	6,052,926
Glacial and loessial:	
Marshall series	8,057,686
Miami series	7,422,760
Volusia series	1,057,570
Miscellaneous soils	5,879,816
Total for province	22,417,832
Glacial lake and river terraces:	
Clyde series	1,211,332
Dunkirk series	880,592
Fargo series	638,208
Merrimac series	506,660
Sioux series	423,610
Superior series	229,184
Vergennes series	169,408
Hudson series	22,144
Miscellaneous soils	1,010,744
Total for province	5,091,882
Residual soils of the western prairie region:	
Vernon series	543,296
Crawford series	541,524
Oswego series	488,141
Miscellaneous soils	252,889
Total for province	1,825,850
Great Basin:	
Jordan series	349,216
Bingham series	206,434
Salt Lake series	162,734
Redfield series	104,724
Malade series	36,096
Miscellaneous soils	146,396
Total for province	1,005,600
Northwestern intermountain region:	
Yakima series	628,182
Gallatin series	400,808
Bridger series	62,016
Miscellaneous soils	364,422
Total for province	1,455,428

Area of the soil series and the combined area of the miscellaneous soils of each of the provinces—Continued.

Province and series.	Acres.	Province and series.	Acres.
Rocky Mountain valleys and plains:		Pacific coast province:	
Colorado series	722,240	Hanford series	622,321
Morton series	464,640	Maricopa series	535,843
Laurel series	363,584	San Joaquin series	530,758
San Luis series	343,040	Placentia series	518,431
Billings series	173,120	Oxnard series	387,462
Laramie series	105,472	Fresno series	304,405
Finney series	60,672	Sierra series	247,031
Mesa series	59,136	Willows series	227,072
Wade series	57,792	Salem series	181,824
Fruita series	4,480	Sacramento series	173,824
Miscellaneous soils	585,664	Stockton series	163,358
		Redding series	71,488
Total for province	2,939,840	Sites series	38,336
		Anderson series	18,048
Arid southwest province:		Miscellaneous soils	573,680
Imperial series	516,416		
Gila series	208,875	Total for province	4,593,881
Indio series	171,904		
Miscellaneous soils	233,960	Total for United States	93,828,114
Total for province	1,131,155		

GENERAL CHARACTER OF THE SOIL PROVINCES AND SOIL SERIES, AND THE RELATIVE VALUE OF THE DIFFERENT SOIL TYPES.

ATLANTIC AND GULF COASTAL PLAINS.

The Atlantic and Gulf Coastal Plains together constitute one of the most important physiographic divisions of the United States. The Atlantic Coastal Plain extends from the New England States southward to the Florida Peninsula, where the Gulf Coastal Plain begins, and extends thence westward to the Mexican boundary line. It is, however, discontinuous, being interrupted by the alluvial bottoms of the Mississippi River. From the coast the Atlantic Plain extends inland to the margin of the Piedmont Plateau—that is, to a line passing through Trenton, Baltimore, Washington, Richmond, Raleigh, Columbia, Augusta, and Macon. In its northern extension it is represented by a narrow belt, but widens in New Jersey and attains its maximum breadth of about 200 miles in North Carolina. The Gulf Plain extends up the Mississippi to the mouth of the Ohio, its inner boundary line passing through or near Montgomery, Iuka, Cairo, Little Rock, Texarkana, Austin, and San Antonio.

The surface is that of a more or less dissected plain marked by few hills, slightly terraced with bluffs along streams. The inner margin of the Coastal Plain is usually from 200 to 300 feet above tidewater, but sometimes rises to 500 feet. The drainage here is usually well established and the surface is rolling to hilly, and consequently carved and eroded. There is a wide belt bordering the coast where the elevations are mostly under 100 feet. North of the James River, where the Coastal Plain is narrow and deeply indented with tidal estuaries, drainage is usually well established and the surface is rolling, but in the broad southern extension, where the seaward slope is hardly more than 1 foot to the mile, drainage is apt to be deficient. Here rain water often remains upon the surface for a considerable time, although the conditions are not comparable with those of a true swamp. The soils in this level section, while composed largely of sand, are compact, usually deficient in organic matter, and not very productive. Many of the flat interstream areas possess such poor drainage that true swamps, such as the Dismal and Okefenokee, have been formed. Near the coast and along the tidal estuaries extensive marshes, separated from the ocean by sand barriers, are found.

The Coastal Plain is made up of unconsolidated gravels, sands, and sandy clays, with less frequent beds of silts and heavy clays. The deposits on the Atlantic coast have been derived mainly from the erosion of the Piedmont Plateau and other inland areas, while the deposits on the Gulf coast have been derived mainly from transported glacial material and from western plains. The materials have been transported and deposited beneath the sea and subsequently exposed by the uplift of the ocean floor. In the more northern parts of the Coastal Plain, and even as far south as Virginia, the character of the deposits has been modified by glacial action and the flooded condition of the streams resulting from the melting of the ice.

The Coastal Plain deposits range in age from Cretaceous to Recent. Although extensive areas of the older sediment are exposed at the surface to form soils, still by far the greater part of the materials is Quarternary or Recent in age.

The soils are for the most part composed of sands and light sandy loams, with occasional deposits of silts and heavy clays. The heavy clays are found principally near the inner margin of the Coastal Plain. The silts, silty clays, and black calcareous soils, upon which the rice and sugar cane industries of southern Louisiana and Texas are being so extensively developed, have no equivalents in the Atlantic division.

The aggregate area of all the soils surveyed in this province is 25,613,666 acres.

Bastrop series.

The Bastrop series represents old alluvial material brought down by streams from the Permian Red Beds and deposited as terraces now almost entirely above overflow. The soils are brown with reddish-brown to red subsoils and constitute very fine farming lands.

The Bastrop silt loam is devoted to cotton and corn. Alfalfa can be successfully grown. Melons and potatoes do well. Some of the type is overflow land and is very productive. The sandy loam is a light river-bottom soil suited to truck and melons, although cotton and corn are extensively grown. The soil needs fertilization with green manure. It has good drainage. The clay is a strong, heavy soil, sometimes subject to overflow, and requiring care in cultivation.

It is especially adapted to corn, yielding large crops, and does well also with cotton. The fine sandy loam in Bastrop and Wilson counties, Tex., is a very productive soil adapted to a wide range of crops. It suffers to some extent from drought, but with careful management to preserve soil moisture it would be a very valuable trucking soil. If irrigated, the highest possibilities of agricultural development could be attained. Cotton, corn, and sorghum give large yields. Oats make a thrifty growth, and alfalfa, grown to some extent, gives good returns. Pecans are indigenous and could be grown on a commercial basis in the river bottoms. Melons, potatoes, peanuts, and vegetables are grown and do exceptionally well. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Bastrop series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Bastrop sandy loam	Texas	7,680
fine sandy loam	do	32,320
silt loam	do	[a]6,080
clay	do	12,352
Total		58,432

[a] Of this amount 1,216 acres in the Austin area mapped as Yazoo sandy loam.

Crockett series.

The Crockett series occurs as isolated prairies in the timbered part of Texas. The soil is gray to dark gray and sometimes almost black in color, while the subsoil is mottled red, gray, and black, the red mottling being the distinguishing characteristic. This series may be considered as representing a gradation from the Houston series, or black prairie soils, to the mottled red clays of the Susquehanna series.

Soils of the Crockett series, being derived from slightly calcareous materials, are productive. The clay loam, the most extensive type, produces yields of cotton above the average and is successfully used for other general farming crops. The loam and fine sandy loam produce fair yields of cotton and corn. The gravelly loam is one of the earliest soils in the region in which it occurs and is adapted to early vegetables and trucking. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Crockett series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Crockett gravelly loam	Texas	3,008
fine sandy loam	do	4,416
loam	do	640
clay loam	do	21,440
Total		29,504

Elkton series.

The Elkton series consists of light-gray to white surface soils with mottled whitish-gray and yellow subsoils. Gravel or coarse sand is usually found at a depth of 2½ to 3 feet below the surface, and is usually saturated with water. This series is closely associated with the Sassafras, and the difference is due to the intermittent wetting and drying to which the Elkton soils have been subjected, causing them to become very much lighter in color and much lower in agricultural value.

The silt loam is much more extensively developed than the other members of this series. It produces good wheat and grass, but poor average crops of tomatoes and corn. The soil is much benefited by turning under green manures and by liming. It should be devoted principally to growing grass and forage crops in connection with stock raising.

The other members of the series are usually in need of drainage, and this as well as liming must be resorted to before the best results can be secured. They are best suited to grass and forage crops. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Elkton series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Elkton sandy loam	Maryland	9,280
fine sandy loam	Virginia	14,656
loam	Maryland	2,624
silt loam [a]	Delaware, Maryland, New Jersey, Pennsylvania	158,292
Total		184,852

[a] Mapped in the Chester County area, Pennsylvania, as the Portsmouth silt loam.

Gadsden series.

The Gadsden series includes dark-gray soils found upon gentle slopes or undulations adjacent to streams and upon level or depressed areas in the uplands. Their formation is due largely to the peculiar topographic conditions resulting from the sinking of the limestones which underlie, in some of the areas, the materials from which the Norfolk and Orangeburg soils have been derived. They may be considered as colluvial soils formed by the creeping or washing of material from higher lying areas. The series is very incomplete, only the sand, sandy loam, and loam members having been encountered.

The Gadsden series is of minor importance as compared with the more extensive Norfolk, Orangeburg, and Lufkin soils, but constitutes valuable farming lands. The sand, which is the most extensive type, is very productive, and of special use in the growing of Florida Sumatra wrapper tobacco. The sandy loam, of limited extent, likewise produces a fine grade wrapper and is good for cotton and corn. Sugar cane does well on the lower lying areas. The loam member, a well-drained, productive soil, is adapted to cotton, corn, and forage crops. Indicated adaptations are truck and tree fruits. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Gadsden series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Gadsden sand	Florida, Georgia	57,344
sandy loam	Florida	6,592
loam	Mississippi	14,592
Total		78,528

Guin series.

The Guin series consists of gray soils with brown to yellowish-red subsoils. This series is closely related to the Orangeburg and the Norfolk series and in position and characteristics is intermediate between the two. It is derived from unconsolidated deposits, principally of the Lafayette formation, and is found near the inner border of the Coastal Plain in northeastern Mississippi and northwestern Alabama. The generally broken and hilly character of the surface renders it of low value for general agriculture.

The soils of the Guin series are still largely in forest and have been improved very little. Cultivated areas produce moderate yields of corn and cotton. It is thought that these soils would make good land for peach culture. The acreage of the different types so far encountered is shown in the following table:

Area and distribution of the soils of the Guin series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Guin stony sandy loam	Alabama	28,032
gravelly sandy loam	do	69,056
fine sandy loam	Alabama, Mississippi	358,016
Total		455,104

Houston series.

The Houston series occurs principally in the black, calcareous prairie regions of Alabama, Mississippi, and Texas. The soils are characterized by a large percentage of lime, especially in the subsoil, which in some of the types consists of white, chalky limestone. The series has been derived from the weathering of calcareous clays, chalk beds, and " rotten " limestones, all of late Cretaceous age. In some localities remnants of later sandy and gravelly deposits have been mingled with the calcareous material, giving rise to the gravelly and loam members of the series.

The soils of the Houston series constitute the fertile black prairies of the Gulf States, and are not found east of Alabama. They are without question the most productive upland soils of the Gulf Coastal Plain, a fact mainly due to their calcareous nature. The Houston black clay, locally known as "black waxy land," is the most extensively developed soil of the series. In the sections where it occurs it is the best cotton soil. In the past it has been used chiefly in the production of this crop, but, being well adapted to alfalfa, in recent years the acreage in this legume has steadily increased. In its virgin state it supported a heavy growth of native prairie grasses and in some sections hay and pasturage are still its important products. The Houston clay, while not as valuable land as the black clay, has a special adaptation for alfalfa, and produces good yields of cotton and the other staple crops. In the vicinity of San Antonio, Tex., there is associated with the Houston black clay a black clay loam soil that is good cotton, corn, and sorghum land, and which, under irrigation, could be profitably used for some truck crops. This type, so far as the soil survey has shown, is one of comparatively limited occurrence. The Houston loam, on the contrary, has been mapped in a number of areas and though not as highly esteemed as the heavier members of the series is considered a good soil for cotton, corn, and sorghum. Being lighter textured, it is less plastic and sticky and may be worked under a wider range of moisture conditions. The gravelly member of the series lies in a semiarid country and is too high for irrigation. Little of it is under cultivation, and its principal value is as pasture. The Houston chalk represents areas where erosion has exposed the Selma chalk, which gives rise to the Houston series. Areas mapped as this last-mentioned type are of little present agricultural use, though by judicious handling they may be improved and can then be utilized for the crops mentioned as doing well on the more important soils of the series. The acreage of the different types so far as mapped is shown in the following table:

Area and distribution of the soils of the Houston series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Houston gravelly clay	Texas	148,416
loam[a]	Oklahoma, Texas	239,296
black clay loam	Texas	54,272
black clay[b]	Alabama, Oklahoma, Texas	1,265,304
clay[c]	Alabama, Kansas, Louisiana, Mississippi, Texas	610,664
chalk	Mississippi	8,064
Total		2,326,016

[a] The soils mapped as Houston silt loam and Houston clay in the Paris area, Texas, are Houston loam.

[b] The soil mapped as Houston clay in the Anderson County area, Texas, is Houston black clay.

[c] The soil mapped as Houston black clay in Macon County area, Alabama, is the Houston clay.

Laredo series.

The Laredo series consists of gray to light-brown calcareous soils with gray calcareous subsoils. They occur as a terrace along streams in south Texas and also constitute the principal soils of the Rio Grande delta above overflow. They are made up largely of material which has been brought down from the calcareous and more arid parts of the State. They are seldom or never overflowed, and constitute very valuable farming lands when irrigated.

Laredo silty clay loam, mapped in Brownsville area, Texas, is a very productive soil and well adapted to growing early vegetables. Profitable yields of corn, cotton, and sugar cane are obtained. Fair yields of both cotton and corn are often secured in a favorable season without irrigation. Lettuce, melons, cauliflower, beets, peas, cabbage, onions, eggplant, cucumbers, tomatoes, carrots, and both sweet and Irish potatoes are all profitably grown under irrigation. Cabbage is the principal crop and the average yield is about 18,000 pounds per acre; the average yield of onions is about the same. Irish potatoes yield from 60 to 70 bushels and sugar cane 25 to 30 tons per acre. The clay loam, also recognized in the Laredo area, Texas, is well adapted to the production of onions, giving an average yield of about 20,000 pounds per acre. Alfalfa has been grown under irrigation, though the stand continues good for only one year. Cabbage, beets, and Irish potatoes do well. Sorghum, cowpeas, and sweet potatoes give good returns. The Laredo silty clay is found in the Brownsville area, Texas. Some alkali areas are found in this soil, but yield readily to treatment. When well drained and put under irrigation good yields of corn, cotton, sugar cane, lettuce, cauliflower, tomatoes, beans, peas, cabbage, and other vegetables are produced. The silt loam has been mapped so far only in the Laredo and Brownsville areas, Texas. This type of soil gives the best returns under irrigation. It is well adapted to onions, which give an average yield of 18,000 to 20,000 pounds per acre. Cotton has been grown under irrigation and where irrigated sweet potatoes produce 150 to 200 bushels per acre. Some corn has been grown on the irrigated land, as have cabbages, beets, turnips, and Irish potatoes. Cabbage yields about 13,000 pounds to the acre. Cowpeas do well on both the unirrigated and irrigated soils.

The clay is covered by a dense growth of mesquite and other native vegetation. It is a productive soil and free from alkali accumulations. It was recognized in the Laredo area, Texas, where it is utilized exclusively as pasture land for stock. If irrigated it would produce many varieties of early vegetables. In the Brownsville area it is used for producing rice, which gives a return of 12 sacks; cotton, which averages 1 bale; and corn, about 30 bushels per acre. Beans, peas, cauliflower, cabbage, tomatoes, lettuce, cowpeas, Irish potatoes, and some celery have been produced on this soil. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Laredo series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Laredo silt loam	Texas	16,768
clay loam	do	704
silty clay loam	do	33,216
silty clay	do	448
clay	do	3,904
Total		55,040

Lufkin series.

The Lufkin series is characterized by gray surface soils and heavy, very impervious, plastic gray and mottled subsoils. The difference between the texture of the surface soil and that of the subsoil is very marked, especially in the sandy loam members.

A large part of the area of the Lufkin series of soils is still covered with forest, and from the character of growth the land is known as "swamp" or "post-oak" land.

These soils in most of the areas so far surveyed are generally lower in agricultural value than the Norfolk and Orangeburg soils, but in some parts of Texas the sandy loam forms the principal agricultural soil, and, without fertilization, produces yields of cotton that are even better than those secured on the Norfolk soils. The sandy loam is also adapted to potatoes, cucumbers, and other truck. Lavaca County, Tex., is the only area surveyed in which the Lufkin sand has been found. This soil is a deep sandy type, with a tendency to drought, and is generally poor, but has a special use in the production of sweet potatoes, and offers opportunity for the development of the early trucking industry. The fine sand is used for cotton and corn. It is better adapted to truck crops and to peaches. Cotton and corn, perhaps, do better on the fine sandy loam, though this soil will be found to be suited to other crops, among which should be included certain kinds of truck and fruit. Nearly 400,000 acres of the clay has been mapped, this being the most extensive soil of the series. While a difficult soil to handle, it has been made to produce as high as 1 bale of cotton to the acre. Grass also does well and it offers opportunities for stock raising. The loam is unimportant in extent, but is a good soil, as indicated by the yields of corn and cotton. It is adapted also to truck crops and strawberries. The acreage of the types, so far encountered, is shown in the table on the following page.

Area and distribution of the soils of the Lufkin series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Lufkin gravelly loam	Texas	58,112
sand	do	63,936
fine sand	do	229,568
sandy loam	do	362,944
fine sandy loam [a]	do	226,752
loam	do	5,376
silt loam	Mississippi	55,808
clay [b]	Alabama, Louisiana, Mississippi, Texas	373,312
Total		1,375,808

[a] The area mapped as Lufkin fine sandy loam in the Austin area, Texas, is the Susquehanna fine sandy loam.
[b] The area mapped in Macon County, Ala., is the Susquehanna clay.

Montrose series.

The Montrose series so far as encountered occurs in the south-central part of Mississippi and extends into Alabama. The surface soils are gray and are underlain by heavy plastic yellow subsoils. The region where this occurs is locally known as "flatwoods" or "hog-wallow prairie." The area so far as seen is thickly timbered with post and scrub oaks and pine. The soils are derived from a deposit of heavy clay immediately overlying a soft chalky limestone.

Cotton is the principal crop on the sandy loam and yields from one-third to one-half bale per acre. Some corn is also produced, but after the first two crops the yields are low. Vegetables will do fairly well on this type, but it is not adapted to fruit. The type is valued at present for timber, which covers practically all of it. Frequently the drainage is inadequate, particularly on narrow strips near streams. On the better drained areas are found good growths of longleaf pine and some oak.

The Montrose clay is not a productive soil. It will produce one or two crops of corn, but the yield quickly declines. The soil is acid and much of it would need to be thoroughly drained before it could be brought under cultivation. The type was recognized in Jasper County, Miss., but such a small area was cultivated that no particular adaptation or yield can be given. The timber growth consists of scrawny post oak and black-jack oak, some other species of oak, and some shortleaf pine. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Montrose series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Montrose sandy loam	Mississippi	20,928
clay	do	43,840
Total		64,768

Myatt series.

The Myatt series occurs in seepy places around the heads of streams or in intermediate position between bottom lands and uplands. The soils are gray, while the subsoils are gray and yellow mottled with white.

The soils of the Myatt series are poorly drained and in part subject to overflow. They are still largely covered by forests. When cleared cotton and corn are the chief crops, the yield of cotton ranging from one-fourth bale to 1 bale per acre, with an average of about one-half bale. With proper drainage the lighter members would be well adapted to truck and small-fruit crops. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Myatt series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Myatt fine sand	Alabama	21,376
fine sandy loam	Alabama, Florida, Louisiana, Mississippi	61,440
clay loam	Mississippi	4,096
Total		86,912

Norfolk series.

The Norfolk series consists of light-colored sandy soils underlain by yellow or orange sand or sandy clay subsoils. Where the drainage is insufficient, the subsoil is often mottled. The members of this series are distinguished from those of the Portsmouth series by the lighter color of the surface material and from those of the Orangeburg series by the yellow color of the subsoils. The members of the Norfolk series, with few exceptions, are special purpose rather than general farming soils.

The series comprises the most important truck soils of the Coastal Plain, the different soils not only being specially adapted to special kinds of crops, but also having a wide general distribution from New York to Texas. Of this series the fine sand taken all in all is the leading soil for general trucking. In earliness it lies between the coarser soils on the one hand and the finer on the other. It is less leachy and droughty than the Norfolk sand or coarse sand, and is more easily kept in a productive state. Besides the lighter truck crops, it is a valuable soil in Florida for the production of a fine grade of Sumatra wrapper tobacco, and in North Carolina and Virginia for cigarette tobacco and peanuts. In Maryland it is the best soil for the French type of tobacco. In trucking areas large acreages are devoted to strawberry culture. In the sea islands of South Carolina it is the principal soil upon which the long-staple cotton industry has been developed.

Of the coarser types of the series the gravel and gravelly loam are not extensively developed and are not at present of much agricultural value. The coarse sand and coarse sandy loam are in the same category, but the Norfolk sand, which is a type of wide distribution, is an important soil because of its extreme earliness, and a consequent special use in the forcing of light truck crops for the very early market. It is a leachy and droughty soil and requires heavy manuring and fertilizing to produce profitable yields. Asparagus has proved a most profitable crop on this soil in North Carolina, and watermelons are grown with success in Georgia, extra early potatoes and lettuce in Virginia. These crops indicate special uses of the Norfolk sand, but there are many others that do equally as well in one or another part of its wide occurrence. A special adaptation in the sea islands is long-staple cotton.

The fine sandy loam is not so valuable for early truck as the fine sand, but is an excellent medium to late truck soil and in some sections it is known as "cabbage land." In North Carolina it is esteemed a better cigarette-tobacco soil than the sandy loam and fully equal to the fine sand. It is better for general farming than the lighter soils of the series, and is used extensively in the production of cotton, being the best of the Norfolk series of soils for growing this crop. In certain parts of Maryland it is a fine general purpose soil, giving good yields of wheat, corn, and hay in addition to heavy truck and fruit, principally peaches.

With a larger acreage than any of the other soils of the Norfolk series, the sandy loam is an important resource of the Coastal Plain. It is used for Irish and sweet potatoes, bright yellow tobacco, cotton, peanuts, and heavy truck crops and fruit. In Maryland some areas are considered the best general farming lands. This single type so far mapped comprises an area about half the size of Belgium.

The loam and silt loam are suited to diversified agriculture, the latter being rather the better soil. In New Jersey and Eastern Shore of Maryland good yields of wheat, corn, and hay are secured, and some dairying is practiced. The soil is used for the same general farm crops around Norfolk and in addition Irish and sweet potatoes are grown to some extent.

The clay is apparently most extensively developed in Alabama. In many cases it needs drainage, and with good cultivation produces good yields of cotton and corn. The table on page 106 shows the acreage of the several types so far encountered.

Area and distribution of the soils of the Norfolk series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Norfolk gravel	Maryland, New Jersey, New York, North Carolina.	138,670
gravelly loam	Alabama, Mississippi, Pennsylvania, Virginia	156,294
coarse sand	Alabama, Georgia, Maryland, Mississippi, New Jersey, New York, North Carolina, South Carolina.	208,450
coarse sandy loam	New York, Virginia	69,184
sand [a]	Alabama, Delaware, Florida, Georgia, Louisiana, Maryland, Mississippi, New Jersey, New York, North Carolina, South Carolina, Texas, Virginia.	2,074,712
fine sand [a]	Alabama, Florida, Georgia, Louisiana, Maryland, Mississippi, New Jersey, North Carolina, Pennsylvania, South Carolina Texas, Virginia.	1,319,164
sandy loam	Alabama, Florida, Georgia, Mississippi, New Jersey, North Carolina, South Carolina, Tennessee, Texas, Virginia.	1.454,898
fine sandy loam [b]	Alabama, Florida, Georgia, Indiana, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, South Carolina, Texas, Virginia.	3,118,980
very fine sandy loam	Florida	768
loam [c]	Alabama, Delaware, Florida, Kentucky, Maryland, Mississippi, New York, Pennsylvania, Virginia.	445,966
silt loam [d]	Alabama, Delaware, Maryland, New Jersey, North Carolina, Pennsylvania, South Carolina, Texas, Virginia.	518,532
clay loam	Virginia	1 856
clay	Alabama, Georgia, North Carolina	105 408
Total		9.612,882

[a] The soils mapped as Norfolk sand in the Craven, N. C., Norfolk, Va., and Perry County, Ala., areas is Norfolk fine sand.
[b] Mapped as Miami fine sandy loam in the Boonville, Ind., area, Norfolk loam in Calvert, Prince George, and St. Mary counties, Md., and as Norfolk sandy loam in Fort Valley area, Georgia.
[c] Mapped in Calvert, Prince George, St. Mary, and Worcester counties, Md., and Perry County, Ala., as Sassafras sandy loam. Mapped in the Long Island, N. Y., area in part as Sassafras sandy loam and in part as Sassafras gravelly loam.
[d] Mapped in Calvert, Cecil, Harford, Prince George, St. Mary, and Worcester counties, Md., and Darlington, S. C., area as Sassafras loam and in the Kent County, Md., and Salem and Trenton, N. J., areas in part as Sassafras loam and Sassafras gravelly loam.

Oktibbeha series.

The Oktibbeha series occurs in the prairie belt of Alabama and Mississippi where it is known as "post-oak prairies." The soils are gray to yellowish brown and are underlain by the brown to brownish-yellow subsoils. This series is closely associated with the Houston soils and is derived from material immediately overlying the Selma chalk. The surface soil of the lighter textured members has been formed from a thin deposit of material probably belonging to the Columbia formation.

The Oktibbeha soils require careful handling, but with proper cultivation they produce good yields of the staple crops of the South. Cotton and corn are the crops on the fine sandy loam, virgin areas producing heavy yields. The silt loam needs drainage and under existing conditions it is considered a poor soil. On the other hand, the clay loam is one of the best cotton soils in Oktibbeha County, Miss., the only place where it has been mapped up to the present time. The clay is a difficult soil to handle and the farmers attach very little value to it. It is mainly used for pasture. Bermuda grass takes possession of the land when cleared. As a rule the soils of this series have not been greatly developed. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Oktibbeha series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Oktibbeha fine sandy loam	Mississippi	17,344
silt loam	do	13,824
clay loam	do	15,360
clay	do	25,920
Total		72,448

Orangeburg series.

The Orangeburg series is derived largely, but not entirely, from the Lafayette mantle of gravels, sands, and sandy clays. The surface soils are usually gray to brown in color, and are invariably underlain at a depth of 3 feet or less by a red or yellowish-red sandy clay. The prevailing red color of the subsoil is the characteristic feature distinguishing the Orangeburg series from the Norfolk series. The Orangeburg soils may be considered as the Coastal Plain equivalent of the Cecil series of the Piedmont Plateau.

The soils of the Orangeburg series are somewhat stronger than the corresponding types of the Norfolk series. They are used for about the same crops. The Orangeburg sand is a fine truck soil, and in Florida is used for growing Sumatra wrapper tobacco under shade. It has characteristics that suggest its adaptation to peach culture. The fine sand is an easily worked soil under a wide range of moisture conditions. It also has a wide crop adaptation, being used for truck, fruit, and the staples—corn and cotton. It is especially adapted to peaches and plums. The sandy loam is likewise adapted both to general farm crops and truck. In Orangeburg County, S. C., it is considered the best general farming soil, and is also used for bright-yellow tobacco, though some of the Norfolk soils give a better quality of leaf. In Florida, Alabama, and Texas it produces a high-grade cigar wrapper and filler leaf. The coarse sandy loam has a rather low agricultural value. With the most extensive development of any of the soils of this series, the fine sandy loam is a very important Coastal Plain soil. Cotton, corn, tobacco (both the bright-yellow cigarette in South Carolina and the Cuban filler cigar types in Alabama and Texas), fruit, and truck are grown. In the Fort Valley section of Georgia it is the principal peach soil, and in east Texas this crop is also an important one. Strawberries and other small fruits thrive. Cotton is the chief crop upon the Orangeburg clay, which is typically the best general farming soil of the series. Grain and forage crops do well upon it and stock raising or dairying are industries that might be introduced. This clay often has a veneering of sandy loam, and in such cases is used to advantage for truck and small fruit. The two types, gravelly sandy loam and loam, have so far been found in limited areas. The latter is an excellent soil for cotton and the staple general farming crops.

The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Orangeburg series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Orangeburg coarse sandy loam	South Carolina	8,256
gravelly sandy loam	Texas	5,376
sand [a]	Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, Texas.	253,760
fine sand	Alabama, Georgia, Louisiana, Mississippi, Texas.	391,104
sandy loam [b]	Alabama, Florida, Louisiana, Mississippi, South Carolina, Texas.	316,224
fine sandy loam [c]	Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Texas.	2,034,816
loam	Florida, Mississippi	3,264
clay	Alabama, Georgia, Mississippi, South Carolina, Texas.	473,664
Total		3,486,464

[a] Mapped in the Darlington, S. C., area as Orangeburg sandy loam.
[b] Mapped in the Darlington, S. C., area as Orangeburg loam.
[c] Mapped in Fort Valley, Ga., Gadsden County, Fla., and Perry County, Ala., areas as Orangeburg sandy loam.

Portsmouth series.

The Portsmouth series is characterized by dark-gray to black surface soils, underlain by yellow, gray, or mottled yellow and gray subsoils. The dark color of the soils is due to an accumulation of organic matter during an earlier or existing swampy condition. This series may be considered as intermediate between the light-colored Norfolk soils on the one hand and the Peat and Swamp areas on the other. The members of the series occupy depressed areas, or areas so flat that the water table is at or near the surface, except where artificial drainage has been resorted to.

Notwithstanding their naturally poorly drained condition, the soils of this series are in most instances easily reclaimed by ditching, and when brought into proper condition are highly productive for both the general farm and special crops. The sandy members of the series are very desirable for strawberries, especially for late varieties. They are also well suited to truck crops, such as cabbage, kale, lettuce, and root crops, and could be used to advantage for celery, onions, and other crops that thrive in soils of high organic matter content. In Duplin County, N. C., the sand and fine sandy loam have been found particularly adapted to the growing of bulbs, large yields of tuberoses, dahlias, and cannas being secured. The heavier members are used chiefly for corn, small grain, and grass, though they are also used in places for celery, onions, and cabbage. A relatively small proportion of this series has been developed and but little of this has been highly developed.

The acreage of the types so far encountered is shown in the following table:

Area and distribution of the soils of the Portsmouth series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Portsmouth sand	Delaware, Florida, Georgia, Maryland, North Carolina, Virginia.	136,320
fine sand	Florida, Georgia, North Carolina	328,000
sandy loam	Delaware, Florida, Maryland, North Carolina, South Carolina, Texas, Virginia.	667,108
fine sandy loam	Florida, Georgia, North Carolina, South Carolina, Virginia.	301,476
loam	Maryland, Mississippi, North Carolina	111,424
silt loam[a]	Kentucky, North Carolina, Virginia	182,656
clay loam	Virginia	2,176
Total		1,729,160

[a] The Portsmouth silt loam in the Chester County, Pa., report is Elkton silt loam, and in the Norfolk, Va., area was mapped as the Leonardtown loam and Leonardtown gravelly loam.

Sassafras series.

The soils of the Sassafras series consist of yellowish-brown surface soils underlain by slightly reddish-yellow or light orange subsoils. At a depth varying from 2½ to 5 feet occur beds of gravel or sand. The soils of this series are distinguished from the Norfolk by the brown surface soils, slightly redder subsoils, the presence of the gravel beds in the lower subsoil, the adhesion of finer particles to the sands, and a higher agricultural value. They have been formed from marine and estuary deposits composed of material derived from the Piedmont Plateau and limestone valleys mingled with glacial material brought down by the larger rivers. They occur as distinct terraces from 10 to 250 feet above sea level in the Coastal Plains around Chesapeake Bay and northward. This series includes some of the most productive soils of the Atlantic seaboard.

The sand and loamy sand are light, well-drained, naturally warm, early soils especially adapted to truck crops like garden peas, asparagus, early Irish potatoes, strawberries, and dewberries. The sandy loam is widely distributed and is a good soil for general farming. It is considered the best tomato soil of the Eastern Shore. Strawberries, potatoes, asparagus, peaches, pears, dewberries, and other small fruit make excellent yields. The crop adaptations and agricultural value of the fine sandy loam are nearly the same as for the sandy loam. It is, however, better suited to grass than the latter type. The loam is probably the best all-round general farming soil of the north coastal plain and gives fine yields of wheat, corn, hay, tomatoes, and other medium truck crops. The type is easily managed and its productiveness easily maintained if sufficient organic matter is supplied and moisture conditions kept favorable. The silt loam is also an excellent soil best suited to general farming. It is not particularly well adapted to truck crops, although tomatoes, cabbages, and some other vegetables do fairly well. The gravelly loam is easily tilled and is an excellent soil for orchard fruits like peaches, plums, and pears, and is also a fair corn soil. The acreage of the several types is as follows:

Area and distribution of the soils of the Sassafras series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Sassafras gravelly loam [a]	Maryland	2,880
sand	do	29,696
loamy sand	do	52,992
sandy loam [b]	do	160,576
fine sandy loam	do	18,496
loam [a]	do	101,760
silt loam	do	130,944
Total		497,344

[a] The soils mapped as Sassafras loam and Sassafras gravelly loam in Calvert, Cecil, Harford, Kent, Prince George, St. Mary, and Worcester counties, Md., Darlington, S. C., Salem and Trenton areas, New Jersey, have been placed in the Norfolk series as Norfolk silt loam.

[b] The soils mapped as Sassafras sandy loam and Sassafras gravelly loam in Long Island, N. Y., Calvert, Prince George, St. Mary, and Worcester counties, Md., and Perry County, Ala., have been placed in the Norfolk series as Norfolk loam.

Susquehanna series.

The Susquehanna series consists of gray and brown surface soils underlain by heavy, plastic, red mottled subsoils. Where the basal clays are exposed by erosion they show brilliant colorings, often arranged in large patches of alternating liver color, red, and white. These clays constitute the oldest shore line and marine deposits along the inland margin of the Coastal Plain. The clay is remarkably plastic and is peculiarly well adapted to brick and tile making.

With the exception of the fine sandy loam, which has the greatest extent, the soils of this series are of low producing capacity. They are covered for the most part with pitch pine, scrub oak, and other forest growth of little commercial importance. The clay, a particularly refractory and undesirable soil, is, except in Texas, scarcely cultivated at all and should remain in forest. More of the clay loam is under cultivation and is best adapted to grain and grass crops. Tillage of the gravelly loam is difficult, but with thorough cultivation and generous fertilization fair crops of cotton and corn are secured. In Maryland the soil is confined mainly to narrow strips extending around the hills. These are generally forested, and both from position and lack of productiveness are little sought for farming land. The fine sandy loam occurs most extensively in Texas, where it is used for a wide diversity of crops, ranging from staple cotton, corn, and forage crops to truck and fruit. It requires careful handling, with attention to rotation and green manuring to maintain it in a productive state. Peanuts and cowpeas, in connection with the raising of hogs, have proved profitable in some sections. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Susquehanna series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Susquehanna gravel	Texas	58,560
gravelly loam	Alabama, North Carolina	21,754
sandy loam	Texas	5,824
fine sandy loam[a]	Alabama, Louisiana, Mississippi, Texas	1,013,696
loam	Texas	3,392
silt loam	Mississippi	9,984
clay loam	Louisiana, Maryland	30,930
clay[b]	Alabama, Louisiana, Maryland, Mississippi, Texas	351,850
Total		1,495,990

[a] Mapped as Lufkin fine sandy loam in the Austin area, Texas.
[b] Mapped as Lufkin clay in Macon County, Ala.

Webb series.

The Webb series is found in the semiarid part of the Coastal Plain of Texas, and consists of brown to reddish-brown soils with reddish-brown to red subsoils. The soils are formed from deposits probably belonging to the Lafayette formation and may be considered as a semiarid equivalent of the Orangeburg.

The Webb series is used to some extent both with and without irrigation for cultivated crops. Most of the area of these soils is, however, at present covered with a thick growth of mesquite and cactus or with valuable native grasses. The Webb loam was recognized in Wilson County, Tex. Cotton, corn, and sorghum are grown, and fair yields are obtained. This is a strong soil adapted to the staple crops and general farming when cleared of mesquite. The fine sandy loam when cleared is easily cultivated. Crops on the irrigated areas of this type do not require so much water as on soils with a lighter textured subsoil. All crops suited to the climatic conditions may be produced and good yields obtained on this soil. It is used in the Laredo area, Texas, where it was first recognized, for growing Bermuda onions, for which purpose it is well suited, where the organic matter content is large. Cabbage, turnips, and beets have been produced to a limited extent. Fruit trees make a good growth, especially where the soil has a silty texture. Sweet potatoes, cowpeas, sorghum and corn do well, even where unirrigated. The soil is suited to tobacco, a fair quality of leaf being obtained. Much of the type is still undeveloped and used for grazing cattle. The fine sand supports a heavy growth of native grasses and is classed as excellent pasture land. In the Laredo area, where it was first recognized, none of the soil is under cultivation, being exclusively used for grazing cattle. The gravelly sandy loam is not well adapted to cultivated crops, as both irrigation and cultivation are difficult. It is naturally better adapted to fruit growing. The type has only been found in the Laredo area, Texas, where none of it is under cultivation, being used exclusively as pasture land. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Webb series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Webb gravelly sandy loam	Texas	53,760
fine sand	do	3,136
fine sandy loam	do	110,528
loam	do	17,088
Total		184,512

Wickham series.

The soils of this series occur as river terraces in the higher part of the Coastal Plain, near its contact with the Piedmont Plateau. They are characterized by reddish or reddish-brown surface soils containing a higher percentage of organic matter than the Norfolk series, and usually overlie reddish, micaceous heavy sandy loam or loam subsoils which become coarser, looser, and more incoherent at about 30 inches. The soils generally have a level or gently undulating surface, are fairly well drained, and possess a retentive subsoil.

The Wickham soils are for the most part productive, having the advantage of alluvial deposits without the disadvantages of overflow and poor drainage. They are, however, of limited occurrence, having been mapped so far in only two areas, both in Virginia. They are, at present, used for general farming. The heavier soils produce large yields of wheat, oats, corn, and hay. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Wickham series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Wickham sand	Virginia	4,416
sandy loam	do	5,120
loam	do	5,952
clay loam	do	2,176
Total		17,664

Wilson series.

The Wilson series, like the Crockett series, occurs as prairies scattered through the timbered region of Texas. The surface soils are very much like the Crockett soils, varying from gray to almost black. The subsoils are mottled gray and drab. This series forms a gradation between the Houston and Lufkin series.

The clay loam is a strong soil, devoted to cotton, corn, oats, and sorghum. The fine sandy loam and loam are droughty soils. Cotton seems to be their best crop. The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Wilson series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Wilson fine sandy loam	Texas	4,288
loam	do	98,880
clay loam	do	71,872
Total		175,040

Miscellaneous soils of the Atlantic and Gulf Coastal Plains.

Important areas of the Acadia silt loam have been mapped in Louisiana and in Arkansas. In the former State very little of the soil is at present under cultivation, but in Arkansas it is used extensively in the production of cotton, corn, and oats. Apples, peaches, pears, plums, and small fruits are produced for home use, and could be grown more extensively. Cowpeas are an important crop and are cut for hay.

Small areas of a soil called Alloway clay have been mapped in New Jersey. It is sedimentary in origin and occupies both rolling uplands and stream bottoms. Fine apples are produced upon it, and grass and wheat thrive.

A limited area of Amite loam has been surveyed. It occurs in Louisiana and is of alluvial origin, though occupying higher flood plains. Corn produces from 30 to 40 bushels per acre and cotton does well. The soil is adapted also to sugar cane and some truck crops.

The Amite sandy loam, a sedimentary second-bottom soil found so far only in Louisiana, is a valuable soil with wide crop possibilities. The determined or suggested adaptations include corn, cotton, oats, sweet and Irish potatoes, sugar cane, and truck.

The Caddo fine sandy loam in point of extent is an important soil of Caddo Parish, La. It is largely occupied by forest and needs drainage. Though used mainly for cotton and corn, of which the yields are large, the soil is probably even better adapted to plants requiring a moist soil, for instance, sugar cane, rice, some truck crops, and strawberries.

Of occurrence only in Louisiana, where about 20 square miles of it have been mapped, the Calcasieu fine sand is a sedimentary soil. It occurs in two phases, a fine sandy loam and fine sand, both of which are adapted to truck and fruit.

The Calcasieu loam, a sedimentary soil of Louisiana, is found in depressions and is poorly drained. It has been found to be an excellent soil for rice, an impervious clay subsoil preventing the waste of water during the flooding period.

A relatively small area of Calcasieu fine sandy loam has been found in Texas and Louisiana. It is a good truck soil and is also adapted to pears and berries.

The Chesterfield sandy loam occupies the greater part of Chesterfield County, Va. It is a soil of uncertain derivation, being partly residual and partly sedimentary. It varies in productiveness, but for the most part gives moderate yields. Wheat, corn, oats, and shipping tobacco are the crops grown. The gravelly soil of this name is little used for cultivation, owing to the difficulties of handling. The least stony areas give fair yields.

Among the most productive soils of New Jersey and Coastal Plain Maryland may be placed the Collington sandy loam. Over 110,000 acres of this soil have been mapped in the two States named. The soil is derived through weathering from a green glauconite sand, the pure greensand being found at an average depth of 30 to 40 inches. The areas of this soil are used for small fruit, nursery stock, truck, and tobacco.

The Crowley silt loam is one of the most extensively developed soils of the southern coastal plain region. It occupies level or slightly rolling prairies and in south Louisiana is considered one of the very best soils for rice growing. Well-drained areas are adapted to cotton and oats.

The Durant sand and the Durant fine sandy loam were mapped in Indian Territory. The former is a light sandy loam of low value for general farm crops. Cotton and corn are the only crops grown on the limited areas under cultivation. The fine sandy loam occupies a rolling plain, is well drained, and easily cultivated. Derived from sandstone with interstratified limestone deposits, the soil is calcareous and above the average in fertility. It is for the most part treeless and was one of the first soils to be settled. While not as productive as contiguous areas of Houston black clay, the better phase of the soil is highly esteemed. Cotton, corn, and oats are the important crops.

The Gainesville sand, of which one comparatively small area has been found in Florida, is well drained and inclined to be droughty. The sand is, however, loamy and underlain by clay at about 3 feet, which has a tendency to maintain a moisture supply in all but extremely dry periods. Sea Island cotton is the principal crop, the soil being especially fitted for the production of this valuable variety. Corn, oats, and peanuts are also successfully produced and some areas are used for general farming and the raising of cattle and hogs.

A better general farming soil than the last described, a greater proportion of the Glenn loam is under cultivation, though there is still much of it in forest. Cotton, corn, and oats are the important crops. Apple trees make a thrifty growth and produce a fruit of good quality.

The Glenn sandy loam is for the most part in forest of oak, with a scattering of pine. Cotton and corn are leading crops, the yields being light and uncertain. Peaches do fairly well. Potatoes, peanuts, and some of the truck crops would give better results than the crops grown at present.

Only one small area of the Greenville fine sandy loam has been mapped to the present time. It is closely related to the Orangeburg fine sandy loam and differs from it in having a red surface soil. It is held to be somewhat more productive than the Orangeburg soil. Being found in Alabama, it is used chiefly for cotton and corn.

The Greenville gravelly sandy loam is a fair type for the production of cotton and corn. It is recognized as very well adapted to peaches, small fruits, and vegetables, and in the early days a very good grade of tobacco was grown for home use.

The Greenville loam is a strong productive soil, especially well adapted to growing cotton, corn, and oats. It is not so well adapted to fruit and vegetables. It maintains improvement well and is not easily exhausted under ordinary treatment. It occurs in small areas.

The Hammond silt loam is a level, poorly drained soil of southeastern Louisiana. It is naturally unproductive, being deficient in organic matter. Sugar cane, oats, small truck, and crab-grass hay are the crops succeeding best on this soil.

The greater part of the Harley sandy loam is still in forest, but small areas planted to corn and cotton give good yields. The soil is better adapted to potatoes, fruit, and truck crops. It resembles some of the typical peach soils of the country and the few trees seen upon it were in a thrifty condition.

The Hempstead loam is a friable soil containing some gravel, with a level surface and good drainage. It produces good crops of corn, potatoes, tomatoes, cabbage, rye, and grass, and is also a fair soil for late truck. This soil has been encountered only in Long Island.

The Lacasine clay loam is a heavy, intractable soil found in depressions in swamps. It has little present agricultural value.

The Lake Charles fine sandy loam, limited to Louisiana and Texas, is a soil of heavy fine sandy loam texture underlain by still heavier material. The surface is marked by sand mounds and the elevation is relatively high, so that drainage is fairly good. It is adapted to crops requiring a moderately light soil and a plentiful moisture supply.

A small area of the Lake Charles loam was mapped in Louisiana. Though heavy and difficult to till, it makes excellent rice land.

The Lamar loam is found in Texas. Little of it is under cultivation, as the surface is rough and eroded and washing is severe when the soil is plowed and allowed to lie unprotected. Its main value is as pasture land.

Another of the miscellaneous soils of Louisiana is the Landry silt loam. This type has a rolling surface and is not irrigable, which prevents its utilization for rice growing. It is a fairly good cotton soil.

The Leonardtown loam is a valuable upland soil of Maryland and Virginia. The surface is slightly rolling, the drainage in most areas is good, and altogether the land is well suited to general farming. The soil has a special value in the production of wheat and grass.

The Leon fine sand, like the sand, is poorly drained and at present valued only for its covering of longleaf pine. Consisting of a sand resting on a sandy subsoil, it would doubtless prove droughty if too thoroughly drained. With care to secure the right moisture conditions, it could be used for certain lines of agriculture, though many years will elapse before reclamation will be economical.

No areas of the Leon sand are under cultivation, the type being poorly drained. It supports a good growth of longleaf pine, which is at present its sole value.

The Mobile clay is a grain and grass soil of limited area. It is poorly drained and of little agricultural value.

The Monroe silt loam, mapped only in Louisiana, is mainly in forest of oak and pine. On the few areas where cultivation has been attempted the crops, cotton and corn, have given small yields.

The Morse clay is another soil of slight extent and little agricultural importance. Where irrigable rice can be grown and well-drained areas are adapted to corn and cotton.

Muck and Peat: These soils are composed largely of organic matter in various conditions of decay, the Muck representing an advanced stage of change in Peat areas. Of relatively limited extent, and poorly drained, these soils are highly valued for their adaptation to special crops, such as celery, onions, peppermint, and cabbage.

Derived from limestone, the San Antonio clay loam, a type found only in western Texas, is a very productive soil. Under irrigation it is an excellent fruit soil. It is also adapted to cotton, corn, sorghum, and hay. Alfalfa gives fair returns.

Sandhill, Dunesand, and Coastal beach consist of deep sands of little or no agricultural value.

Swamp, Tidal swamp and marsh: Under these heads are grouped areas covered with water the greater part of the year and unfit for agriculture except where drained and protected from tidal or fluvial overflow. When reclaimed much of this land will become very productive.

The Travis gravelly loam, found in Texas, is composed of old alluvium forming terraces along streams. The high location, together with the large quantity of gravel in the soil and subsoil, renders the type droughty, and it is valued more for its forest growth than for farming. On level areas cotton, corn, and oats give light yields. The soil seems better adapted to tree fruits and melons than for general farm crops.

The Warsaw sandy loam is a well-drained second-terrace soil found in Alabama. This is a productive type well suited to general farm crops and to certain truck crops. On the more elevated areas small fruits and peaches do well.

The acreage of the miscellaneous types described above is as follows:

Area and distribution of the miscellaneous soils of the Atlantic and Gulf Coastal Plains.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Acadia silt loam	Arkansas, Louisiana	225,792
Alloway clay	New Jersey	22,484
Amite loam	Louisiana	16,320
Amite sandy loam	do	7,232
Caddo fine sandy loam	Louisiana, Texas	151,680
Calcasieu fine sand	Louisiana	13,970
Calcasieu loam	do	51,280
Calcasieu fine sandy loam	Louisiana, Texas	28,540
Chesterfield gravelly sandy loam	Virginia	34,304
Chesterfield sandy loam	do	95,680
Collington sandy loam	Maryland, New Jersey	110,886
Crowley silt loam [a]	Arkansas, Louisiana	477,120
Durant fine sandy loam	Oklahoma	25,728
Durant sand	do	4,288
Gainesville sand	Florida	7,744
Glenn loam	Alabama	35,584
Glenn sandy loam	do	73,600
Greenville gravelly sandy loam	Louisiana	10,752
Greenville fine sandy loam	Alabama	9,152
Greenville loam	Louisiana	2,048
Hammond silt loam	do	70,976
Harley sandy loam	Oklahoma	8,832
Hempstead loam	New York	53,824
Lacasine clay loam	Louisiana	3,470
Lake Charles fine sandy loam	Louisiana, Texas	182,708
Lake Charles loam	Louisiana	6,378
Lamar loam	Texas	5,696
Landry silt loam	Louisiana	37,696
Leonardtown loam [b]	Kentucky, Maryland, Virginia	196,834
Leon fine sand	Florida	17,728

[a] Mapped in part as Miami clay loam and in part as Elmira silt loam in the Stuttgart area, Arkansas.

[b] The Leonardtown loam and Leonardtown gravelly loam in the Norfolk, Va., report are the Portsmouth silt loam.

Area and distribution of the miscellaneous soils of the Atlantic and Gulf Coastal Plains—Continued.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Leon sand	Florida	61,376
Mobile clay	Alabama	896
Monroe silt loam	Louisiana, Mississippi	300,992
Morse clay	Arkansas, Louisiana	7,424
Muck and Peat	Florida, Louisiana	65,558
San Antonio clay loam	Texas	28,608
Sandhill, Dunesand and Coastal beach.	Delaware, Florida, Georgia, Maryland, New York, North Carolina, South Carolina, Texas, Virginia.	182,664
Swamp, Tidal swamp and marsh	Delaware, Florida, Georgia, Louisiana, Maryland, New York, North Carolina, South Carolina, Texas, Virginia.	932,218
Travis gravelly loam	Texas	25,728
Warsaw sandy loam	Alabama	33,408
Total		3,627,198

RIVER FLOOD PLAINS.

An extensive and characteristic group of soils, usually known as "bottom lands," is found in the flood plains of numerous rivers and streams of the United States. The largest development of this group occurs along the Mississippi River, where the bottoms are often many miles in width.

The soils have been formed by deposition from stream waters during periods of overflow. The texture of the material depends upon the velocity of the current at the time of the deposition. Where the current is very rapid, large stones and bowlders are borne along and beds of gravel and sand are formed. Along the swift-flowing streams the texture of the soil changes often within short distances, but in wide bottoms large areas of very uniform soils are often formed. The soil material has usually been derived from various kinds of rocks, but in some instances is closely related to the surrounding geological formation. The red soils along the Red and other rivers in the Southwest have been formed by the reworking of the Permian Red Beds. In general, the soils along the streams which flow through the prairie region have a darker color than those along the streams which run only through the timbered sections of the country.

The difference in the origin, drainage, color, and organic matter content has given rise to several series of alluvial soils in the humid portion of the United States.

The aggregate area of the soils surveyed in this province is 8,061,453 acres.

Congaree series.

The soils of the Congaree series are brown to reddish-brown in color, and are composed of material which has been washed from the red Cecil soils of the Piedmont Plateau. As the latter series is derived from crystalline rocks, the Congaree soils usually contain considerable amounts of mica. While they are found along streams in the Piedmont Plateau, they also occur along streams issuing from this region.

The Congaree soils, which occur in small, narrow areas along the streams in all parts of the Piedmont section of the South, are highly valued because of the fine crops of corn that can be harvested year after year upon them. Being subject to overflow, with annual deposition of material washed from fertile upland soil, their productiveness is kept at a high point, and they are so situated that even in dry years the moisture conditions are very favorable. Sorghum and sugar cane are two other crops that produce well. Cotton is apt to run to weed and to mature late, causing a loss of a part of the bolls through frost. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Congaree series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Congaree fine sandy loam	South Carolina	23,360
loam	Alabama, Mississippi, South Carolina, Virginia	140,416
clay[a]	Alabama, South Carolina	19,456
Total		183,232

[a] Mapped as Ocklocknee clay in Macon County, Ala.

Huntington series.

Throughout the area of the Allegheny Plateau there are found along the streams areas or strips of overflow bottom lands, varying in width from a few yards to 3 or 4 miles. The soils are formed by the reworking of materials derived from sandstones, shales, and limestones. Those having a dark-brown to yellow-brown color have been included in the Huntington series.

Somewhat more extensively developed than the Wheeling soils, the Huntington soils, with the exception of the gravelly loam, are very valuable for both general farm crops and truck. The loam is used largely for trucking; the silt loam for corn, potatoes, hay, and truck, with some areas in sorghum and alfalfa. The fine sandy loam is apportioned between the general farm crops mentioned and garden vegetables. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Huntington series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Huntington gravelly loam	Tennessee	14,464
fine sandy loam	Indiana, Pennsylvania, West Virginia	20,864
loam	Indiana, New York, Pennsylvania, Tennessee, Virginia, West Virginia.	101,824
silt loam	Alabama, Indiana, New York, Ohio, Tennessee, Virginia.	121,344
Total		258,496

Miller series.

The soils of the Miller series are distinguished from those of the Wabash and Waverly series by their reddish color. They occur along the Red and other rivers that flow through the Permian Red Beds and represent this material reworked by streams. As these streams flow away from the areas covered by the Red Beds, material from the surrounding country is added, so the soils gradually lose their red color and change to the Wabash or Waverly series.

Soils of the Miller series are among the most productive alluvial soils of the United States. The Miller fine sand gives moderate yields of cotton and corn, and higher lying areas seem adapted to fruit, especially peaches. Vegetables also do well. The fine sandy loam, a more extensive member of the series, gives better yields of cotton and corn, and is also well adapted to truck and fruit, peaches, plums, and pears being grown to considerable extent in parts of Texas. It is also an excellent soil for alfalfa, the acreage of which has been rapidly extended in recent years. Vegetables may be grown with profit, and in some cases irrigation is practiced, the water being secured from artesian wells. The silt loam has about the same extent as the fine sand. It is used for about the same crops as the fine sandy loam and clay, i. e., cotton, corn, sugar cane, and alfalfa. The clay is the most extensive and strongest soil of the series. Surpassed by few soils in the production of cotton and alfalfa, it is no less valuable in the growing of sugar cane. The Miller soils from their origin and the relatively circumscribed area of the formation from which they are derived are not an extensive series. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Miller series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Miller fine sand	Arkansas, Louisiana, Texas	66,944
fine sandy loam	Arkansas, Louisiana, Oklahoma, Texas	177,216
loam	Oklahoma	37,184
silt loam [a]	Louisiana, Texas	54,208
clay [b]	Arkansas, Louisiana, Oklahoma, Texas	260,352
Total		595,904

[a] Mapped as Vernon silt loam in Vernon area, Texas.
[b] Mapped as Sharkey clay in Miller County area, Arkansas.

Ocklocknee series.

The Ocklocknee series occurs as the better drained bottom lands in the Coastal Plains region, principally of Georgia, Alabama, and Mississippi. It is formed by the reworking of noncalcareous unconsolidated deposits. The soils are gray to yellowish-brown and do not show a large amount of mottling.

The soils when well drained are among the most productive soils in the Coastal Plains. Very little of the clay is as yet cultivated, although it is capable of producing large yields of cotton and corn. Some excellent pasture is found, but the soil will not be used much for agricultural purposes until the streams are put under better control and the drainage improved. The loam is at present valued largely for its timber. It would require a large expenditure to put it into cultivation and prevent the injury to crops by inundation. When well drained it will produce good crops of both corn and cotton. The fine sandy loam usually lies higher above the stream than the heavier soil, but much of the type requires drainage. When this is done it proves a good cotton and corn soil. The sand is very limited in extent and is of little importance agriculturally. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Ocklocknee series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Ocklocknee sand	Alabama	960
fine sandy loam	do	28,544
loam	Mississippi	103,360
clay loam	do	13,632
clay [a]	Alabama, Florida, Georgia, Mississippi	89,920
Total		236,416

[a] The soil mapped as Ocklocknee clay in Macon County, Ala., is Congaree clay.

Wabash series.

The Wabash series comprises the most important of the alluvial types of soil. It embraces those soils having a dark-brown to black color and a large percentage of organic matter. These soils are typical of the Mississippi River, but there is no sharp distinction between them and other bottom soils found along the rivers of the Middle West.

The Wabash soils are among the strongest and most productive types of the country.

The most extensive type of the series is the silt loam, by far the greater part of which is found north of the southern tier of States, and therefore cotton is not as important a crop as corn, grass, and small grains, of which fair to large yields are secured, depending upon the condition of drainage. The next soil in point of area is the Wabash clay. In the Southern States this is considered the best cotton soil, producing on the average over a bale of lint to the acre. Farther north it gives large yields of corn. A small area of the heavy clay has been found in Texas, where it gives heavy yields of cotton, corn, oats, and forage crops. The Wabash loam is the third soil in area; occurring to the north of the cotton sections it is used chiefly for corn, to which it is well adapted. It can be used to advantage in the production of canning crops, such as sugar corn, tomatoes, green peas, and beans. The fine sandy loam is of limited extent. Some areas produce heavy yields of wheat, oats, corn, while others are better suited to melons, sugar beets, Irish potatoes, and alfalfa. The principal crop on the sandy loam is corn. It is also suited to truck crops. The heavier silt loam and clay loam are both valuable soils, though as yet only small areas have been encountered in the soil survey. Heavy yields of grass, corn, alfalfa, Kafir corn, sorghum, and moderate yields of small grains are obtained. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Wabash series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Wabash fine sand	Arkansas, Oklahoma	19,008
sandy loam [a]	Indiana, Ohio	6,624
fine sandy loam [b]	Arkansas, Indiana, Minnesota, Nebraska, Oklahoma.	71,872
loam [c]	Arkansas. Illinois, Michigan, Minnesota, Missouri, New York, North Dakota, Ohio, Wisconsin.	264,176
silt loam [d]	Alabama, Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Minnesota, Missouri, Nebraska, Oklahoma, Tennessee.	854,366
silt clay	Kansas, Oklahoma	9,984
clay loam	Arkansas	11,584
clay [e]	Alabama, Arkansas, Illinois, Kansas, Louisiana, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, Texas.	610,635
heavy clay	Texas	13,248
Total		1,861,497

[a] Mapped as Miami sandy loam in the Montgomery County area, Ohio.
[b] Mapped as Miami sandy loam in Posey County, Ind.
[c] Mapped as Miami loam in Auburn, Lyons, and Syracuse areas, New York; Columbus, Coshocton, and Montgomery counties, and Toledo and Westerville areas, Ohio; Fargo and Grand Forks areas, North Dakota; Marshall area, Minnesota; Pontiac area, Michigan; and Viroqua area, Wisconsin, and as Lintonia loam in Tazewell County, Ill.
[d] Mapped as Lintonia loam in the Dubuque area, Iowa, and as Waverly silt loam in Posey County, Ind., and Union County, Ky.
[e] Mapped as Yazoo clay and Sharkey clay in Allen County, Kans., and as Sharkey clay in Parsons area, Kansas.

Waverly series.

The Waverly series is characterized by light-colored surface soils, with drab, gray, and mottled yellow or white subsoils. The soils of this series occur almost entirely along the streams east of the Mississippi River.

Though occupying the same position as the Miller and Wabash series, the Waverly soils are decidedly less productive. They range from fine sandy loam to clay, and in general are used for corn and cotton. The fine sandy loam is adapted to corn, melons, early vegetables, and alfalfa, while wheat, oats, and potatoes are successfully grown. The loam is, according to location, adapted to cotton and corn, or to corn, wheat, and forage crops. Overflows render the successful use of this soil problematical in certain areas. Corn is the principal crop on the silt loam, and in the South cotton is also an important crop; the yields are good. The soil has a marked adaptability for sugar cane, giving large yields of a superior quality of sirup. Cabbage and peas are grown, and other truck crops could be produced on a commercial scale. The clay loam seems best adapted to clover, timothy, and redtop. Export tobacco, wheat, and corn are other products of this soil, the yields depending on the character of drainage and cultivation. On well-drained areas of the clay, where protected from overflows, corn, wheat, grasses, oats, and tobacco yield well. The heavier members of this series have not been developed to so great an extent as the corresponding types of the Wabash series. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Waverly series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Waverly fine sandy loam [a]	Illinois, Indiana, Kentucky, Mississippi	18,176
loam [b]	Alabama, Indiana, Mississippi, Tennessee	182,016
silt loam [c]	Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri, Tennessee.	393,472
clay loam [d]	Illinois, Indiana, Missouri	68,224
clay [e]	Alabama, Arkansas, Indiana, Kentucky, Mississippi, Ohio.	220,352
Total		882,240

[a] Mapped as Miami fine sandy loam in Posey County, Ind., and Union County, Ky., and as Yazoo sandy loam in Clay County, Ill.
[b] Mapped as Yazoo loam in Posey County, Ind.
[c] The soil mapped as Waverly silt loam in Posey County, Ind., and Union County, Ky., is Wabash silt loam.
[d] Mapped as Guthrie clay in Posey County, Ind.
[e] Mapped as Yazoo clay and Sharkey clay in Union County, Ky.

Wheeling series.

About the close of the Glacial epoch there was formed along the Ohio and other rivers issuing from ice-covered regions a series of gravel terraces. The terrace soils which have been formed by streams issuing from areas where the upland soils are composed of ground-up sandstone and shales have been included in the Wheeling series. The gravel is composed largely of sandstone and shale, although granite and other crystalline rocks are also present. Shale being a rather soft rock, the percentage generally decreases as the distance from the source of the material decreases. The soils are brown to yellow brown in color and are underlain by gravel, usually within 3 feet of the surface.

While of limited extent the Wheeling soils are important in relation to other soils of the region where they occur. The gravelly loam—the most extensive soil—has a wide adaptation, being suited to the production of the general farm crops, truck, and fruit. The sandy loam is especially adapted to apples, and is nearly all occupied by bearing orchards. The silt loam is a well-drained terrace soil, and is valued as a potato soil, though producing fine crops of tomatoes, corn, wheat, and hay. The fine sandy loam is best adapted to melons and strawberries. Other small fruits do well, while the staples—potatoes, corn, wheat, and hay—are grown with good results. About the same crops are produced on the fine sand with marked results with melons and tomatoes.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Wheeling series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Wheeling gravelly loam	Ohio, West Virginia	11,392
fine sand	Ohio	640
sandy loam	West Virginia	768
fine sandy loam	Ohio	1,984
silt loam	Ohio, West Virginia	5,248
Total		20,032

Miscellaneous soils of the river flood plains.

In this province, where the soils are now forming or have recently formed, a good many soils have been encountered which have no such common properties as to suggest definite relationships that would justify their being put into any one of the established series, but it is not unlikely that with further work in the extension of the surveys new series may be established and some of these miscellaneous soils be brought into them. The various uses to which these miscellaneous soils are now being put are briefly shown in the following paragraphs:

On the Austin fine sandy loam the corps grown are cotton, corn, fruit, and some vegetables. Considerable sorghum fodder is produced, and under favorable conditions it is thought alfalfa would make abundant crops.

The Biscoe silt loam in Arkansas is well adapted to cotton and corn, which are the principal crops grown on it. It would probably do well if planted to alfalfa, and with proper cultural methods prove an excellent truck soil.

The Blanco loam occurs in such small areas that it is of minor importance, but is productive, especially when irrigated. It makes good yields of corn, cotton, Irish potatoes, and sweet potatoes. It is well suited to vegetables. Large yields of alfalfa are secured when irrigated.

Only limited areas of the Brennan fine sandy loam are cultivated. Favorable seasons tend to make fair yields of corn, cowpeas, and sorghum on this soil. It is chiefly valued as pasture land.

The Calhoun clay is poorly drained, but if drained should prove a good soil for cotton.

The Cameron clay was formerly used for rice culture in Texas, but accumulations of salts have discouraged the cultivation of this crop. Where well drained good yields of the general farm crops are secured.

Little of the Carrington clay loam is under cultivation. It is a difficult soil to till, but should produce good yields of wheat.

The Catalpa silt loam requires drainage, but when reclaimed is a very valuable general farming soil.

The Chattooga loam is a productive soil for corn.

In Arkansas, where it occurs, the Collins silt loam produces cotton, corn, and potatoes.

The Franklin loam is little cultivated. It produces some cotton and corn.

The Griffen clay is largely covered with forest. Corn is the chief crop on cultivated areas, and some wheat and oats are grown.

The Jackson loam is used for wheat and corn. It is adapted to light farm crops and truck, wrapper tobacco, and peaches.

The Lintonia loam is a good cotton soil and well adapted to market gardening and fruit culture. In northern areas it produces corn, wheat, oats, and potatoes.

The Lomalto clay is affected with alkali and the opportunity for drainage is poor, so that little agricultural value attaches to this soil.

Meadow consists of low-lying, flat, and poorly drained land of variable texture. Frequently of some value for grass and pasturage, and in the South for corn after subsidence of floods. Much more of it can be reclaimed by simple methods of drainage, and when this is done excellent results can be secured from a variety of crops.

Muck and Peat are soils composed largely of organic matter in various conditions of decay, the Muck representing an advanced stage of change in Peat areas. Of relatively limited extent, and poorly drained, these soils are highly valued for their adaptation to special crops, such as celery, onions, peppermint, and cabbage.

The Neosho silt loam is best adapted to wheat and grass, but in normal seasons corn and oats do well. The soil is in need of drainage.

The Neuse clay is poorly adapted for agriculture on account of its close, sticky nature and poor drainage, but when well drained is a good cotton soil.

The Point Isabel clay is of little agricultural value.

The Rio Grande silty clay, a semiarid type of soil, is largely covered with native vegetation of water-loving species. Without irrigation a few areas produce corn and cotton.

The Sanders silt loam is subject to overflow, but under favorable conditions makes good crops of corn, cotton, and Johnson and Bermuda grasses. Heavy yields of sirup are secured.

The Sanders loam is a very good corn soil, but not so well suited to the production of cotton. It generally needs drainage.

When well drained the Sarpy clay loam makes excellent corn land. It is used to some extent for alfalfa, of which excellent yields are secured.

The Sharkey clay lies along streams in the South, where it is locally known as "Buckshot land." When diked and well drained it is a strong soil, suited to corn, sugar cane, and cotton.

Swamp and Marsh comprise areas covered with water the greater part of the year and unfit for agriculture except where drained and protected from tidal or fluvial overflow. When reclaimed much of this land will become very productive.

The principal crops grown on the Teller fine sandy loam are cotton and corn. The Teller fine sand, in addition to cotton and corn, of which very fair yields are obtained, is well adapted to potatoes, melons, and other truck crops and to fruits.

The Toxaway fine sandy loam and loam are among the most productive soils of the mountain valleys where they occur. The loam is used for corn, hay, and wheat. The fine sandy loam, while used for the same crops, is really better suited to the production of vegetables, melons, and other truck crops.

The Tyler silt loam is poorly drained, crawfishy land. It is not well adapted to wheat, but fair yields of oats and corn are secured. It is mainly used for grazing or pasture lands.

The Yazoo sandy loam occupies low, flat ridges forming front lands near stream courses. The chief product is cotton, but the soil is suited to truck and market garden crops. Corn and truck do well in the more northern area.

The Yazoo loam is used chiefly for cotton, but it is by nature better adapted to truck and market garden crops. The loam is a strong cotton soil. In northern areas it is adapted to corn and wheat.

The acreage of the types so far encountered is given in the following table:

Area and distribution of miscellaneous soils of the river flood plains.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Austin fine sandy loam	Texas	32,576
Biscoe silt loam	Arkansas	12,992
Blanco loam	Texas	5,376
Brennan fine sandy loam	do	11,584
Calhoun clay	Arkansas	12,672
Cameron clay	Texas	27,072
Carrington clay loam	North Dakota	6,272
Catalpa silt loam	Mississippi	5,056
Chattooga loam	Alabama	5,696
Collins silt loam	Arkansas	8,576
Franklin loam	Texas	1,280
Griffin clay	Indiana	1,60[illegible]
Jackson loam	Missouri	2,30[illegible]

Area and distribution of miscellaneous soils of the river flood plains—Continued.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Lomalto clay	Texas	36,544
Lintonia loam [a]	Illinois, Indiana, Kentucky, Mississippi	87,540
Meadow	Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Wisconsin	2,369,335
Muck and Peat	Kentucky, Louisiana, Nebraska	24,640
Neosho silt loam [b]	Kansas	30,739
Neuse clay	Mississippi, North Carolina	17,952
Point Isabel clay	Texas	4,096
Rio Grande silty clay	do	8,064
Rock outcrop, etc	Indiana, Kentucky, Missouri, North Dakota	20,416
Sanders loam	Texas	17,408
Sanders silt loam	do	10,880
Sarpy clay loam	Nebraska	2,816
Sharkey clay [c]	Louisiana, Mississippi, Texas	760,764
Swamp and Marsh	Alabama, Arkansas, Connecticut, Delaware, Florida, Louisiana, Maryland, Massachusetts, Mississippi, North Carolina, Texas, Virginia.	116,206
Teller fine sand	Oklahoma	1,344
Teller fine sandy loam	do	11,712
Toxaway fine sandy loam	North Carolina, Virginia	25,152
Toxaway loam	North Carolina	11,328
Tyler silt loam	West Virginia	3,008
Yazoo loam [d]	Illinois, Kansas, Louisiana, Mississippi, Missouri, Texas.	168,067
Yazoo sandy loam [e]	Illinois, Indiana, Kansas, Louisiana, Mississippi, Texas.	162,363
Total		4,023,430

[a] The area mapped as Lintonia loam in Tazewell County, Ill., is Wabash loam, that mapped as Lintonia loam in the Dubuque area, Iowa, is Wabash silt loam, and that mapped as Memphis silt loam in Posey County, Ind., and Union County, Ky., is Lintonia loam.

[b] Mapped as Oswego silt loam in Parsons area, Kansas.

[c] The soil mapped as Sharkey clay in Union County, Ky., is the Waverly clay, and that mapped as Sharkey clay in Miller County, Ark., is the Miller clay. The area mapped as Sharkey clay in Allen County and Parsons area, Kansas, is Wabash clay.

[d] The soil mapped as Yazoo loam in Posey County, Ind., is Waverly loam.

[e] The area mapped as Yazoo sandy loam in Clay County, Ill., is Waverly fine sandy loam. In the Austin area, Texas, 1,216 acres of Yazoo sandy loam republished as Bastrop silt loam in Bastrop County, Texas, and included in the latter type.

PIEDMONT PLATEAU.

Lying between the Atlantic Coastal Plain and the Appalachian Mountains and extending from the Hudson River to east-central Alabama is an area of gently rolling to hilly country known as the Piedmont Plateau. On the Atlantic side it is closely defined by the "fall line," which separates it from the coastal plain, but on the northwestern side the boundary is not sharp, although in the main distinct. In its northern extension the Piedmont Plateau is quite narrow, but broadens toward the south, attaining its greatest width in North Carolina.

The surface features are those of a broad, rolling plain that has been deeply cut by an intricate system of small streams, whose valley walls are rounded and covered with soil, although many small gorges and rocky areas occur. The altitude varies from about 300 feet to more than 1,000 feet above sea level.

The extreme northern part of the Piedmont region, in New Jersey, has been glaciated, but elsewhere the soils are purely residual in origin and have been derived almost exclusively from the weathering of igneous and metamorphic rocks. The chief exception is the detached areas of sandstones and shales of Triassic age. Marked differences in the character of the rock and the method of formation has given rise to a number of soil types, those derived from crystalline rocks being the most numerous and widely distributed. Among these the soils of the Cecil and Chester series predominate. The principal types formed from the sandstones and shales are included in the Penn series.

The aggregate area of the soils surveyed in this province is 7,271,798 acres.

Cecil series.

The Cecil series includes the most important and widely distributed soils of the Piedmont Plateau. The heavier members are known as the "red-clay lands" and are characterized by red clay subsoils, with gray to red soils ranging in texture from sand to clay, the lighter colors prevailing with the sandy members. A characteristic of the subsoil is the sharp quartz sand, which is always scattered through it, and occasional veins of quartz or flint rock. Particles and flakes of mica are usually present in the subsoil. The types are of residual origin derived from the degradation of igneous and metamorphic rocks which have been weathered generally to great depths, so that outcrops are rare. Fragments and bowlders of the parent rocks are, however, found on the surface in varying quantities. The topography is rolling to hilly, with level areas existing where stream erosion has not been too great.

The soils of the Cecil series produce general farm crops throughout their extent and in the South cotton is the important crop. Both heavy export and bright tobacco are generally grown, the character of the leaf produced depending on the depth and texture of the soil. The clay is the typical soil of the Piedmont Plateau and occupies two-fifths of the total area of the series, as shown by the surveys to the present time. It is recognized as the strongest soil for general farming. It is adapted to grass, wheat, and corn in Maryland and Pennsylvania, and export tobacco, wheat, and grass in Virginia, cotton, with corn and wheat secondary, in the Carolinas and Georgia. Cowpeas succeed on this soil perhaps as well as anywhere in the country. The sandy loam, while not as strong a soil as the clay, is generally preferred by the farmers on account of greater ease of cultivation. It is the lightest soil of the series suitable for general agriculture. In the South cotton is the leading crop, with corn next in importance. In Virginia and the Carolinas it is used both for bright-yellow and dark-shipping tobacco. Besides these staples a great variety of minor crops is produced. Next in extent is the Cecil sand, which is generally recognized as the bright tobacco soil of the Piedmont region. It is especially adapted to sweet potatoes and watermelons. The silt loam and loam are types of moderate productiveness and are used in the production of corn, cotton, wheat, oats, and tobacco. The fine sandy loam is used chiefly for corn and cotton. It produces fine-textured tobacco, and is also suited to the growing of peaches and plums. The stony loam is found mainly in the more northern States, where it is a good general farming and apple soil. A relatively small area of the clay loam has been mapped. It is an excellent corn soil and produces fair crops of wheat, oats, and hay. So far this soil has been found only in Pennsylvania. Of small extent, the gravelly loam and stony clay have little importance. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Cecil series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Cecil stony loam[a]	Alabama, New Jersey, Pennsylvania, South Carolina.	125,993
stony clay	Alabama, South Carolina	19,136
gravelly loam	South Carolina	23,744
sand	Georgia, North Carolina, South Carolina, Virginia.	259,744
sandy loam	Alabama, Georgia, North Carolina, South Carolina, Virginia.	2,110,808
fine sandy loam	South Carolina, Virginia	186,560
loam[b]	Virginia	112,362
silt loam	North Carolina, South Carolina, Virginia	172,596
clay loam	Pennsylvania	45,376
clay	Alabama, Georgia, Maryland, North Carolina, Pennsylvania, South Carolina, Virginia.	2,135,427
Total		5,191,746

[a] Mapped as Cecil clay (stony phase) in the Lebanon area, Pennsylvania, and as Cecil loam in the Trenton area, New Jersey.

[b] The soil mapped as Cecil loam in Adams County, Pa., Albemarle area, Appomattox County, and Leesburg area, Virginia, and Cecil and Hartford counties, Md., is Chester loam.

Chester series.

The Chester series occurs in the northern part of the Piedmont, having been found and mapped only in Pennsylvania, Maryland, and Virginia. This series differs from the Cecil series in having yellow or only slightly reddish subsoils and gray or brown surface soils, which are on the whole lighter and more friable than those of the Cecil series. The members of this series are also much more micaceous and even more subject to erosion than the soils of the Cecil series. Locally they are known as "gray lands" to distinguish them from the "red lands" of the Cecil series. The topography in general is not so rough, being rolling to moderately hilly.

The soils are of residual origin, derived from igneous and metamorphic rocks, principally mica schists. The weathering has not gone on so deeply as in the case of the Cecil series, and the underlying rock is often encountered within 2 feet of the surface on slopes where erosion is pronounced and rarely lies more than 10 to 15 feet below the surface.

The Chester soils occur with the Cecil series in Pennsylvania, Maryland, and Virginia. They are not so strong as the Cecil soils, and require more careful handling to maintain the yields, but they are generally better developed. Only four members of this series have been mapped. Of this by far the greater area is occupied by the loam. While used mainly for general farming and especially adapted to corn, it is also well adapted to fruit growing, thrifty apple orchards having been found both in Pennsylvania and Virginia. In Maryland it is used for canning crops, sweet corn and tomatoes occupying important positions. The mica loam is devoted to the same crops as the loam, but is a lighter soil and not equal to it in fertility. Although limited in area, the fine sandy loam is a desirable soil for early garden crops and potatoes. Permanent pastures are found over the greater part of the stony loam. Where the surface features are favorable, however, corn, oats, wheat, potatoes, and hay are grown to some extent.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Chester series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Chester stony loam	Pennsylvania	20,864
fine sandy loam	do	6,080
mica loam	Maryland, Pennsylvania, Virginia	65,778
loam [a]	Maryland, Pennsylvania, Virginia, West Virginia	599,976
Total		692,698

[a] Mapped as Cecil loam in Adams County, Pa., Albemarle area, Appomattox County, and Leesburg area, Virginia, and in Cecil and Harford counties, Md.

Penn series.

The Penn series consists of Indian or purplish red soils derived from the weathering of red sandstones and shales of Triassic age. Detached areas of Triassic rocks occur in shallow basins in the Piedmont from New England to South Carolina.

Though of less extent than the Hagerstown and Cecil series, the Penn series comprises some important agricultural soils. The principal type is the Penn loam, a friable loamy soil well suited to general farm crops and considered almost equal to associated limestone soils in productiveness. It is especially adapted to grass and grain and is well suited to dairying. The Penn stony loam is used for orcharding and the less stony areas for general farm crops. Another stony type is the shale loam, which occurs principally in Pennsylvania. It is used for general farming, producing fair crops of corn, wheat, oats, and hay. The sandy loam is easily tilled, but produces only light yields, which are compensated in a measure by uniformly good quality. The silt loam and clay are strong soils, producing fine yields of the general farm crops, wheat, corn, and grass.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Penn series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Penn stony loam	Connecticut, Massachusetts, New Jersey, Pennsylvania, Virginia.	174,788
shale loam	Pennsylvania	100,032
gravelly loam	Maryland, Virginia	704
sandy loam [a]	New Jersey, Pennsylvania, Virginia	60,366
loam	Maryland, New Jersey, Pennsylvania, Virginia	300,746
silt loam	Pennsylvania	61,824
clay [b]	Maryland, Virginia	27,904
Total		726,364

[a] The soil mapped as Penn sandy loam in the Fort Payne area, Alabama, is the Upshur sandy loam.
[b] The soil mapped as Penn clay in the Syracuse area, New York, is Upshur clay.

Miscellaneous soils of the Piedmont Plateau.

The Bradley sandy loam is a residual soil derived mainly from granite and gneiss, modified to some extent by the admixture of sedimentary material. It makes moderate yields of corn, oats, and wheat.

The Brandywine loam is a general farming soil of moderate productiveness.

The Cardiff slate loam occurs in Maryland and Pennsylvania. The interstitial material is rather heavy, but the soil is friable because of the presence of slate fragments. It is mostly forested with oak, chestnut, and other hardwood trees. Cleared areas produce fair crops of corn, wheat, oats, and grass.

The Conowingo barrens is of no agricultural value. The closely related Conowingo clay is a moderately productive soil, used in general farming.

Though extensively developed in Virginia and the Carolinas, the Iredell clay loam, because of a waxy, impervious subsoil, is not esteemed a very desirable soil for any of our common crops. Some areas, however, give fair yields of cotton, corn, and wheat.

The Lansdale silt loam is above the average in productiveness. It is used for the general farm crops.

For corn the Loudoun sandy loam is considered a fine soil. Wheat gives only moderate yields. Grass and clover are also grown with good results.

The Manor loam, found only in Pennsylvania, produces fair yields of the general farm crops, and the Manor stony loam, where cultivation is possible, is used for the same line of agriculture.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, Riverwash, is mainly nonagricultural land.

The small area of Worsham sandy loam occurs in Virginia. This soil is poorly drained, and is best used for grass, pasture, and hay.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the Piedmont Plateau.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Bradley sandy loam	Virginia	59,072
Brandywine loam	Pennsylvania	24,000
Cardiff slate loam	Maryland, Pennsylvania	2,458
Conowingo barrens	Maryland, Pennsylvania, Virginia	15,200
Conowingo clay	Maryland, North Carolina, Pennsylvania, Virginia.	49,894
Iredell clay loam	North Carolina, South Carolina, Virginia.	239,018
Lansdale silt loam	Pennsylvania	99,136
Loudoun sandy loam	Maryland, Virginia	27,968
Manor loam	Pennsylvania	76,736
Manor stony loam	do	38,956
Rock outcrop, Rough stony land, Steep broken land, Rough broken land, Riverwash.	Alabama, Pennsylvania, South Carolina.	20,032
Worsham sandy loam	Virginia	8,520
Total		660,990

APPALACHIAN MOUNTAINS AND PLATEAU.

The Appalachian Mountains are made up of a number of parallel ranges and intervening valleys, which extend in a general northeast and southwest direction from southern New York to northern Alabama. The elevation ranges from about 1,500 to nearly 7,000 feet above sea level, the highest point being attained in western North Carolina.

Immediately west of the Appalachian Mountains and usually separated from them by a valley is a wide stretch of country known as the Allegheny Plateau. In a broad way this plateau is carved out of a great block of sedimentary rocks tilted to the northwest from the mountains. It is crossed by numerous streams. As they run in deep channels (all the larger ones being from 200 to 1,000 feet in depth) the dissection of the plateau block is often minute.

The rocks of the eastern ranges of the Appalachian Mountains are igneous or metamorphic in origin, while the western ranges, as well as the Allegheny Plateau, are made up of sedimentary rocks. Different series of soils have, therefore, been formed in different parts of these mountains and plateau. The igneous and metamorphic rocks give rise to the soils of the Porter series, while the Dekalb and Upshur series are formed from the weathering of the sandstones and shales of sedimentary origin.

The character of the topography in the mountain and much of the plateau region is such that general farming is not practicable. These areas are, however, well suited to grazing and fruit growing, and these are very important industries.

The aggregate area of all the soils surveyed in this province is 6,367,009 acres.

Dekalb series.

The Dekalb series is derived from the disintegration of sandstones and shales, from Silurian to Carboniferous in age. The surface soils are gray to brown in color, while the subsoils are commonly some shade of yellow. The surface features consist of gently rolling tablelands, hills, and mountains.

The soils of this series are generally not very productive.

The stony and sandy members of the series are well adapted to orchard and small fruits, while the heavier soils make good hay and pastures. The yields of the cereal crops are small, but the quality of the products in general is good. The stony loam and stony sandy loam, owing to character of surface and the very stony nature, are not desirable soils to cultivate, but with proper location and elevation have proven well adapted to peaches. The shale loam is a heavy soil, and is adapted to grain and grass crops. In most localities it is devoted entirely to these crops. The yields are fair. The gravelly loam does fairly well for the general farm crops, but is generally droughty. The gravelly and fine sandy loam are fairly good soils for truck and fruit. The loam is a naturally well-drained soil, and is the best general farming soil in this series, producing potatoes, vegetables, melons, small fruits, and tobacco, as well as the general farm crops. The silt loam and clay are heavy soils that do best to the grain and grass crops, but because of the hilly surface much of these types should not be cultivated. As a whole, the soils of the Dekalb series are covered to great extent by forest growth, the predominant growths being chestnut and oak and other hardwood trees of less prominence.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Dekalb series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Dekalb stony loam	Alabama, Maryland, North Carolina, Pennsylvania, Tennessee, Virginia, West Virginia.	749,396
shale loam	Kentucky, Maryland, Tennessee, Virginia, West Virginia.	481,012
gravelly loam	Pennsylvania	4,800
stony sandy loam	do	18,688
sandy loam	Alabama, Ohio, Pennsylvania, Tennessee, West Virginia.	539,796
fine sandy loam	Alabama, Kentucky, Missouri, Pennsylvania, Virginia.	113,344
loam	Kentucky, Pennsylvania, West Virginia	102,336
silt loam	Alabama, Indiana, Kentucky, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia	701,568
clay [a]	Alabama, New York, Ohio, Pennsylvania, West Virginia.	153,380
Total		2,864,320

[a] Mapped as Dunkirk shale loam in the Westfield area, New York.

Fayetteville series.

The Fayetteville series consists of grayish-brown to brown soils with yellowish-brown to reddish-brown subsoils. They are intermediate between the Dekalb series and the Upshur series. They are formed by the weathering of sandstones and shales and are found throughout a large part of western and northwestern Arkansas and eastern Oklahoma. They are considered moderately fertile soils.

The stony loam is the most extensively developed. The surface is rolling to hilly and in some places the slopes are subject to injurious washing. The least stony parts are fairly well adapted to the production of general farm crops, and in favorable positions apples and peaches do well. Grapes are also grown in some sections with success. Under the present conditions the more hilly and stony areas can best be utilized as pasture. Where the topographical position is favorable, the fine sandy loam is exceptionally well suited to peaches. Apples and small fruits, especially strawberries, do well. Moderate yields of the general farm crops are readily obtained and it is considered the best potato soil in this section. The loam is a good general farming soil, and satisfactory yields of corn, oats, wheat, and grass may be readily secured where the type is efficiently farmed. Its productiveness is much better maintained than the fine sandy loam. Excellent yields of strawberries are secured on the well-drained portions, but they are not quite as early as those grown on the fine sandy loam. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Fayetteville series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Fayetteville stony loam	Arkansas	118,400
fine sandy loam	do	17,216
loam	do	44,352
Total		179,968

Porter series.

The Porter series includes the residual soils of the Appalachian Mountains derived from igneous and metamorphic rocks. The soils are analogous to those of the Cecil series, but are classed separately on account of the difference in topographic position. The mountainous character of the country in which the Porter soils are found renders them difficult of cultivation. They occur at high elevations and so are influenced more or less by different climatic and drainage conditions.

The soils of the Porter series are all eminently adapted to fruit culture, except the higher and rougher portions, and especially so at medium elevations and under suitable conditions of slope and exposure. Fruit forms the principal crop and the industry seems destined to take on much larger proportions. The black loam is the most prominent, being especially adapted to the production of the Albemarle Pippin apple, which attains perfection in the sheltered coves having a northeasterly exposure. On the broad, rolling tops of the mountains the situation is too high and exposed for fruit culture, but such areas make excellent grazing. The loam, clay loam, and clay are the general farming types of the series, but the Porters clay is also important as an apple soil, producing the red varieties of apples, as the Winesap and others, to perfection. The sandy types, where not too rough or at too high elevation, are especially adapted to peach culture and are so used extensively. A number of varieties of peaches succeed on these soils. They will also produce good crops of grapes. Cattle grazing is also an important industry of the Porters series of soils, and on the more level and less elevated areas the general farm crops, as wheat, corn, rye, and barley, are grown. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Porter series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Porters stony loam	Georgia, North Carolina, Pennsylvania	81,734
sand	North Carolina, South Carolina, Virginia	216,710
sandy loam	do	393,305
fine sandy loam	South Carolina	24,128
black loam	North Carolina, Virginia	193,550
loam	North Carolina, South Carolina	436,160
clay loam	South Carolina	26,432
clay	North Carolina, Pennsylvania, South Carolina, Virginia, West Virginia.	292,509
Total		1,664,528

Upshur series.

The Upshur series is closely associated with the Dekalb series, but is much less extensively developed. It is characterized and distinguished from the Dekalb series by brown and red surface soils and red subsoils. The series has been formed by the weathering of red sandstones and shales of Paleozoic age. The surface is rolling to mountainous, and drainage is well established.

The soils of the Upshur series are generally more productive than the corresponding members of the Dekalb series. The sandy loam and loam are well drained, and when well cultivated yields fairly good crops of cotton, corn, wheat, and the forage crops. The clay is a heavy soil, and occurring on steep hillsides suffers much from erosion. It is mainly used for pasturage, but the less hilly areas, susceptible of thorough cultivation, produce good crops of wheat, corn, and grass. The stony loam, stony sandy loam, and sandy loam are adapted to fruit. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Upshur series.

Soil name.	States in which each type has been found.	Total area,
		Acres.
Upshur stony loam	Arkansas, Pennsylvania	62,912
stony sandy loam	Pennsylvania	2,368
sandy loam[a]	Alabama, Arkansas	8,896
fine sandy loam	Arkansas	17,472
loam	Alabama, Arkansas, Pennsylvania	28,416
silt loam	Virginia	2,624
clay[b]	New York, Ohio, West Virginia	41,216
Total		163,904

[a] Mapped as Penn sandy loam in Fort Payne area, Alabama.
[b] Mapped as Penn clay in Syracuse area, New York.

Miscellaneous soils of the Appalachain Mountains and Plateau.

The Chandler stony loam is of little agricultural value, hardly at all developed, and is covered with forest growth.

Very little of the Chemung stony loam is under cultivation, although it is fairly productive. This is largely due to its rough and rolling topography. It may prove a valuable fruit soil.

A steep ridge soil, the Clinch shale loam has little value except for pasturage.

The Conway silt loam is a transitional type between uplands and flood plains. It is not generally adequately drained, but where moisture conditions are properly controlled good crops of cotton and corn may be grown.

The Grainger shale loam, so far as encountered, is a rough ridgy soil and fit only for grazing stock.

Corn and wheat are the principal crops of the Holston loam. It is not considered a productive soil.

The Lickdale clay loam is low-lying and naturally refractory land, and best suited to grass and pasturage. The stony loam is a poor soil, but with improvement, through careful cultivation, it might be used in some areas for peach culture.

The Meigs clay loam is a comparatively extensive soil in southeastern Ohio, where it is used both for pasture, being naturally adapted to bluegrass, and for growing wheat, oats, and hay. It is not a very strong soil, but responds to fertilization and good treatment.

The Morrison sand forms a part of what are locally known as the "barrens," in the limestone valleys of Pennsylvania. It is of very low agricultural value and adapted mainly to forestry.

The Morrison fine sandy loam is not adapted to general farming, and the yields of corn, wheat, and oats are comparatively low. It is of very limited occurrence.

The Morrison sandy loam, which occupies ridges and slopes in the "barrens" of Pennsylvania is not adapted to general farming, but should be suited to trucking and the production of fruits. Pears in the area surveyed in Pennsylvania appeared especially thrifty.

Very little of the Montevallo stony loam is under cultivation. The cleared areas give small yields of cotton. Some areas may some day prove valuable for peach culture.

The Pilot loam produces average yields of corn, wheat, oats, grass, and forage crops. The Pilot gravelly loam is for the most part incapable of cultivation on account of gravel and stone content, otherwise it makes fair yields of the general farm crops.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash, are mainly nonagricultural land.

The Talladega slate loam is extensively developed in Alabama, but the greater part of it is still wild land. Cleared areas are used for cotton and corn. The stony loam is largely under cultivation to cotton, making fair yields. With better market facilities, it would be a valuable soil for peach and small fruit culture.

The Paris loam and Indian loam are unimportant soils.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the Appalachian Mountains and Plateau.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Chandler stony loam	Alabama	1,664
Chemung stony loam	Pennsylvania	3,328
Clinch shale loam	Tennessee	26,752
Conway silt loam	Arkansas	38,912
Grainger shale loam	Tennessee	20,288
Holston silt loam	Tennessee, Virginia	576
Holston loam	Tennessee	1,472
Indian loam	Virginia	384
Lickdale clay loam	Pennsylvania, Tennessee	33,040
Lickdale stony loam	Alabama	4,416
Meigs clay loam	Ohio	395,712
Montevallo stony loam	Alabama	4,032
Morrison fine sandy loam	Pennsylvania	1,600
Morrison sand	do	576
Morrison sandy loam	do	2,560
Paris loam	Virginia	1,536
Pilot gravelly loam	do	2,752
Pilot loam	South Carolina, Virginia	42,752
Rock outcrop, Rough stony land, Rough broken land, Riverwash.	Alabama, Arkansas, Kentucky, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia.	800,833
Talladega slate loam	Alabama	95,552
Talladega stony loam	do	15,552
Total		1,494,289

LIMESTONE VALLEYS AND UPLANDS.

The limestone soils are among the most extensively developed of any in the United States and occur in both broad upland and inclosed narrow valley areas. The greatest upland development is seen upon the Cumberland Plateau in eastern Tennessee and Kentucky and upon the Carboniferous formation in central Tennessee and Kentucky, northern Alabama and Georgia, and in Missouri. The valley soils are found principally in Pennsylvania, Maryland, and Virginia, and in the mountain section of eastern Tennessee and Kentucky and northern Alabama and Georgia. The topography of the plateau soils varies considerably. In the Cumberland Plateau and Highland Rim the surface is undulating; in the region of the Ozark uplift in Missouri and Arkansas it is quite rough and hilly, and where there is an elevation of the surface, or where the plateau is deeply dissected by erosion, it presents a quite mountainous topography. The valley soils of the Appalachian region also show considerable topographic relief, sometimes exhibiting mountainous surface features.

The limestone soils are residual in origin, being derived from the weathering in place of limestone of differing age and composition. This is accomplished by the removal through solution of the calcium carbonate of the limestone, leaving behind the more resistant siliceous minerals. These soils are remarkable for the fact that they contain but a very small percentage of the original limestone rock, the larger part having gone into solution. It has thus required the solution of many feet of rock to form a single foot of soil. Thus far the limestone soils east of Kansas and Texas and north of central Alabama and Georgia have been grouped in two important series, known as the Hagerstown and Clarksville.

The aggregate area of the soils surveyed in this province is 6,052,926 acres.

Clarksville series.

The Clarksville series is derived largely from cherty and fossiliferous limestone of the St. Louis group of the Subcarboniferous formation. These soils occur in both the level and undulating uplands and in rough, hilly country with steep valleys. When the latter surface features predominate the soils are generally unproductive and very stony, but in some sections are adapted to fruit, especially apples. The soils formed from beds of purer limestone occupying level and gently rolling areas are, as a rule, very productive, and are adapted to wheat, corn, and tobacco.

The soils of the Clarksville series are not nearly so productive as those of the Hagerstown, yet they are important agriculturally as producing special crops. The stony loam and silt loam, usually occurring together, are the most extensive and widely distributed of the series. The former has become prominent in the fruit industry in the Ozark Plateau region, where it is extensively used in the production of apples and peaches. The silt loam is generally known as "Barrens" and "Flatwoods," and is largely forested, but late years have seen the specializing of cantaloupe and strawberry growing on this soil in the Highland Rim region of Tennessee. In Tennessee and Kentucky this soil produces an excellent grade of export tobacco. It is a droughty soil and not considered strong, but with good treatment fair yields of the staple crops can be produced. The clay loam is a strong, fertile soil and considered the best general farming soil of the series. It produces heavy yields of the export variety of tobacco, but not a superior quality of leaf. A large part of these soils is forested, the growth consisting mostly of oaks, but other trees are also represented. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Clarksville series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Clarksville stony loam [a]	Alabama, Arkansas, Missouri, Tennessee	2,277,140
gravelly sandy loam	Alabama	5,376
fine sandy loam	do	1,856
loam	Alabama, Tennessee	86,720
silt loam	Alabama, Arkansas, Kentucky, Missouri, Tennessee.	1,215,362
clay loam [b]	Kentucky, Tennessee	36,868
Total		3,623,322

[a] The soil mapped as Clarksville stony loam in the Dubuque area, Iowa, and Wichita area, Kansas, is now classed as Rough stony land.

[b] The soil mapped as Clarksville clay loam in Lauderdale County, Ala., and Lawrence County, Tenn., is the Hagerstown loam.

Cumberland series.

Many of the larger streams traversing the limestone regions formerly flowed at considerably higher levels, and this resulted in the formation of more or less distinct erosion terraces. Upon these terraces was deposited a thin stratum of sedimentary material. The surface soils are therefore partly sedimentary, while the subsoils are residual from the underlying limestones. The surface soils are brown to yellowish brown in color, while the subsoils are yellow to reddish yellow.

The Cumberland series comprise high terrace soils in the limestone region of the South. The loam is adapted to the general farm crops, to truck, and to fruit. In its more southern areas cotton is an important and very profitable crop. A small area of fine sandy loam has been mapped. This member of the series is used chiefly for corn and cotton, but is also adapted to small fruits and vegetables, though these latter crops are not grown on the areas encountered to the present time. Only a limited area of the gravelly loam and clay loam has been found.

The acreage of the types so far mapped is as follows:

Area and distribution of the soils of the Cumberland series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Cumberland gravelly loam	Virginia	3,840
fine sandy loam	Alabama	4,864
loam	Kentucky, Tennessee, Virginia	60,480
clay loam	Virginia	192
Total		69,376

Decatur series.

The Decatur series consists of reddish-brown to red soils with intensely red or blood-red subsoils. The deep-red color forms their distinguishing characteristic. They are derived from rather pure hard limestones, and outcrops of the underlying rock are not uncommon. They form valley lands occurring principally in east Tennessee and Alabama.

The Decatur soils have an agricultural value intermediate between the Hagerstown and the Clarksville series. The clay, which has been found only in Tennessee, and a great part of which is not under cultivation, makes excellent bluegrass pasture. Less stony areas produce moderate yields of corn and wheat. On the other hand, the clay loam is an excellent general farming soil. In Tennessee it gives good crops of wheat, oats, and grass and other forage crops. In Alabama it is a strong cotton soil, and is also good grass land, heavy yields of both orchard and Johnson grass being secured. The silt loam, while a good general farming type, has been found to be especially well adapted to cantaloupes. The loam likewise is a fine general farming soil. It produces good crops of cotton and corn. Cotton and corn are also produced to advantage on the stony loam, which in addition, in lighter phases, is well adapted to peach culture. Some fine commercial orchards are established on this soil.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Decatur series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Decatur stony loam	Alabama	85,696
loam	do	25,664
silt loam	Tennessee	960
clay loam	Alabama, Tennessee, Virginia	63,104
clay[a]	Tennessee	15,040
Total		190,464

[a] The soil mapped as Decatur clay in the Greenville area, Tennessee, is Hagerstown clay.

Hagerstown series.

The Hagerstown series is formed mainly from the solution and subsequent filtration of pure massive limestone of Cambro-Silurian age. The soils of this series, as a rule, occur in valleys bordered by areas of the more resistant sandstones and shales. The series is most typically developed in the limestone valleys of the Allegheny Mountain region and in the central basins of Kentucky and Tennessee, but smaller areas are found as marginal deposits in the adjoining Piedmont section and in the deep valleys of the Appalachian Plateau, where the underlying limestones have been exposed to weathering by previous deep erosion. The most productive valley phase occurs in the large valley between the Blue Ridge and the Allegheny Mountains.

The important loam and clay types form the greater part of the Hagerstown soils so far covered by the soil survey. It is these two soils that have given agricultural prominence to the limestone valleys of the eastern United States. The production of wheat has continued upon these soils notwithstanding the competition of the wheat lands of the West. They constitute the bluegrass region of Kentucky and Tennessee and comprise the lands of the important Burley tobacco district. The loam is the typical upland corn soil of the valley region of central Pennsylvania, Maryland, and the Shenandoah Valley of Virginia. Important tomato-canning industries have been developed in sections. As an apple soil it has produced, par excellence, the Winesap, York Imperial, and some other varieties, and extensive commercial orchards are found. The clay loam is recognized as one of the strongest soils for general agricultural purposes and is well known for its large crops of wheat, corn, and grass. The stony and sandy soils have a special adaptation for fruit, commercial orchards of peaches and apples being established in many sections of the valley region.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Hagerstown series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Hagerstown stony loam	Alabama, Pennsylvania, Tennessee, Virginia	288,494
stony clay	Alabama, Kentucky, Tennessee	50,432
sandy loam	Alabama, Pennsylvania, Tennessee, Virginia, West Virginia.	74,246
loam [a]	Alabama, Kentucky, Tennessee, Pennsylvania, Virginia.	1,045,702
silt loam	Pennsylvania, Virginia	54,592
clay loam	do	28,936
clay [b]	Alabama, Kentucky, Pennsylvania, Tennessee, Virginia, West Virginia.	347,482
Total		1,889,884

[a] Mapped as Clarksville clay loam in Lauderdale County, Ala., and Lawrence County, Tenn., and as Davidson loam in Davidson County, Tenn.

[b] Mapped as Decatur clay in the Greeneville area, Tennessee.

Miscellaneous soils of the limestone valleys and uplands.

The Brooke clay loam is a limestone soil found in West Virginia in the region bordering the Ohio River. It has considerable value for general farm crops.

The Conestoga loam of Lancaster and Montgomery counties, Pa., is recognized as an excellent soil for general agriculture. Though a very refractory soil, its known high productiveness for wheat and grass makes the Conestoga clay one of the most desirable soils in the Shenandoah Valley of Virginia.

The Davidson loam is a limestone soil, modified by material derived from strata of sandstone and shale. It is used for the same crops as the Hagerstown loam.

The Fort Payne clay loam is an undesirable soil and best suited for pasturage. The sandy loam on the other hand is a valuable soil found in Michigan. It is suited to a variety of crops, and has a marked adaptation for potatoes, which are of superior quality. Besides the general farm crops it is well fitted to produce sugar beets and other special crops.

The Guthrie clay and silt loam constitute the "crawfish lands" occupying depressions in limestone areas. While of some value for their timber growth, they are extremely poor soils for agricultural purposes in their present undrained condition.

The disintegration of the water-lime rocks in Pennsylvania gives rise to the Frankstown stony loam, a soil easily tilled and quite generally cultivated. It is devoted to general farm crops, of which wheat and corn yield well. This soil should be used more extensively for clover, pasture, or meadow in order to increase the humus and prevent washing and leaching.

The Moccasin stony clay occupies steep slopes with outcropping limestone. It is difficult to cultivate and is best suited to stock raising.

The Murrill clay loam produces good crops of wheat, corn, grass, and dark shipping tobacco.

The Newman stony loam has very limited extent; being rough it is little suited to cultivated crops. Grazing is its principal use.

The Radford loam is a high terrace soil of moderate productiveness. It is used chiefly for corn and wheat, with hay as a secondary crop. Some of it is used for pasture. It has a wide range in value, the poorer areas being valued at $10, and from this the price ranges to $100 an acre.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the limestone valleys and uplands.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Brooke clay loam	West Virginia	38,464
Conestoga clay	Tennessee, Virginia	64,128
Conestoga loam	Pennsylvania	52,344
Davidson loam [a]	Tennessee	20,352
Fort Payne clay loam	....do	9,536
Fort Payne sandy loam	Michigan	7,936
Frankstown stony loam	Pennsylvania	2,048
Guthrie clay [b]	Alabama, Arkansas, Kentucky, Tennessee.	53,608
Guthrie silt loam	Alabama, Tennessee	448
Moccasin stony clay	Tennessee	3,840
Murrill clay loam	Virginia	15,720
Newman stony loam	Tennessee	896
Radford loam	Virginia	704
Rock outcrop, Rough stony land, Steep broken land, Rough broken land, Riverwash.	Missouri, Tennessee	9,856
Total		279,880

[a] The soil mapped as the Davidson loam in Davidson County, Tenn., is the Hagerstown loam.
[b] The soil mapped as Guthrie clay in Posey County, Ind., is Waverly clay loam.

GLACIAL AND LOESSIAL REGIONS.

The soils of the glaciated part of the country constitute one of the most important groups in the United States. This group includes all soils derived directly from till or loess. The soils formed from the till are confined to that part of the country lying north of the southern limit of glacial action, but the loess soils occur also south of this line, especially along the Mississippi and Ohio rivers and in Kansas and Nebraska. The line of the southern extension of the ice sheet touches the Atlantic coast about New York City, passes through northern New Jersey, southern New York, and northwestern Pennsylvania, swings southwestward through Ohio to Cincinnati, crosses the Mississippi River at St. Louis, and follows the south side of the Missouri River into Montana, where it crosses the Canadian boundary line, then dips southward into Idaho as a long lobe in the mountainous nonagricultural region, and crosses the northwestern part of Washington, including the Puget Sound region.

Practically all of the United States north of this line was covered in recent geological time by a great continental glacier, many hundreds, and even thousands, of feet in thickness. This great ice sheet, moving in a southern direction, filled up valleys, planed off the tops of hills and mountains, ground up the underlying rocks, carried the derived material both within and upon the ice, and finally deposited the gravel, sand, silt, and clay as a mantle, varying in thickness from a few feet to more than 300 feet. Often this material has been transported hundreds of miles, and is wholly unrelated to the underlying rocks, but in some places the movement has been slight, and the drift consists very largely of the ground-up underlying rock. Over a large proportion of the area covered by the drift and also along the Ohio and Mississippi rivers and in Kansas and Nebraska the surface material consists of a fine silty deposit, known geologically as "loess" and "plains marl." In the classification of the glacial soils three important series—Miami, Marshall, and Volusia—having distinct characteristics have been recognized, and, in addition, quite a number of miscellaneous soils which can not be put in any series.

The aggregate area of the soils surveyed in this province is 22,417,832 acres.

Marshall series.

The Marshall series includes the dark-colored upland glacial and loessial soils, which cover almost all of the great prairie region of the central West. The soils of this series are characterized and distinguished from those of the Miami series by the relatively large quantity of organic matter in the surface soils, which gives them a dark-brown to black color. The topography is level to rolling, and artificial drainage is necessary on many level and low-lying areas to secure the best results. The soils of this series are very productive and constitute the great corn soils of the country.

The Marshall silt loam, loam, and clay loam constitute the principal soil types throughout the great corn belt and rank among the most productive of our general farming soils. In Iowa, Illinois, and Nebraska corn, oats, clover, and timothy are the leading crops, while in Minnesota and the Dakotas wheat becomes of primary importance. The Miami black clay loam when drained is also an exceedingly fertile soil, being particularly well adapted to corn. The sandy loam and fine sandy loam, while not so well adapted to general farming as the heavier soils, are quite productive and have a wide crop adaptation. The sand and fine sand are well suited to truck crops, but give rather uncertain yields of general farm crops.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Marshall series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Marshall stony loam	North Dakota, South Dakota	84,096
gravel[a]	Minnesota, North Dakota	2,560
gravelly loam	Kansas, Minnesota, North Dakota, Wisconsin	106,816
sand	Indiana, Iowa, Wisconsin	52,736
fine sand	Indiana, Iowa, Minnesota, Nebraska, North Dakota.	54,272

[a] The soil mapped as Marshall gravel in Pontiac area, Michigan, is Miami gravelly sand.

Area and distribution of the soils of the Marshall series—Continued.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Marshall sandy loam	Illinois, Indiana, Kansas, Minnesota, South Dakota.	261,440
fine sandy loam	Indiana, Minnesota, Nebraska, North Dakota	111,168
loam	Illinois, Indiana, Iowa, Michigan, Minnesota, Nebraska, North Dakota, South Dakota, Wisconsin.	1,680,832
silt loam [a]	Colorado, Illinois, Indiana, Iowa, Kansas, Louisiana, Minnesota, Missouri, Nebraska, North Dakota, Wisconsin.	4,454,470
clay loam	Iowa, Minnesota, North Dakota, Wisconsin	600,320
black clay loam [b]	Illinois, Indiana, Iowa, Michigan, Minnesota, North Dakota, Ohio, South Dakota, Wisconsin.	572,176
clay	North Dakota	76,800
Total		8,057,686

[a] Mapped as Miami silt loam in Clinton and St. Clair counties, Ill., and as Fresno fine sandy loam in Lower Arkansas Valley area, Colorado.
[b] The soil mapped as Miami (now Marshall) black clay loam in the Toleda area, Ohio, is Clyde clay.

Miami series.

The Miami series is one of the most important, widely distributed, and complete soil series that has been established. The series is characterized by the light color of the surface soils, by derivation from glacial material, and by being timbered either now or originally. The heavier members of the series are better adapted to wheat than the corresponding members of the Marshall series, but they do not produce as large yields of corn.

The clay loam is the most important for general farming, and forms the principal type of soil in western Ohio and central and eastern Indiana. It is especially well adapted to small grain and grass crops. The silt loam is more rolling and hilly than the clay loam and is not so well suited to general farming. Wheat does better upon it than upon the Marshall silt loam, with which it is closely associated, but the yields of corn are considerably less. It is also well adapted to fruit, especially apples. The sandy loam and fine sandy loam are used for general agriculture, but are especially adapted to medium and late truck crops and fruit. The loam is suited to corn and potatoes, while small grain and grass are grown, but with less success than upon the clay loam. Strawberries and raspberries, as well as other small fruits, do well on this type. The stony sand, gravelly sand, and gravel are not of much agricultural value under present conditions. The stony loam is a good general farming soil, is also well adapted to apples, and furnishes excellent pasture, while in New York alfalfa is grown upon it very successfully. The stony sandy loam and gravelly sandy loam are not strong soils, but are fairly well suited to light farming, fruit, and truck. The sand and fine sand are not adapted to general farming, but are the best early truck soils of this section.

The acreage of the different types so far encountered is as follows:

Area and distribution of the soils of the Miami series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Miami stony sand	Michigan, New York, Washington, Wisconsin	100,278
stony sandy loam	New York, Rhode Island, Vermont, Washington	267,328
stony loam	Michigan, Minnesota, New York, Ohio, Rhode Island, Washington, Wisconsin.	879,094
gravel	Illinois, Wisconsin	21,376
gravelly sand [a]	Michigan, Washington	91,242
gravelly sandy loam	Indiana, Michigan, Minnesota, Washington	58,624
gravelly loam [b]	Indiana, Michigan, Ohio	71,232
sand	Indiana, Kansas, Michigan, Minnesota, Nebraska, Ohio, Wisconsin.	795,720
fine sand	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, New York, Wisconsin.	263,564
sandy loam [c]	Indiana, Iowa, Michigan, Minnesota, Ohio, Washington, Wisconsin.	745,460
fine sandy loam [d]	Indiana, Michigan, New York	130,816
loam [e]	Indiana, Michigan, Wisconsin	214,720
silt loam [f]	Illinois, Indiana, Iowa, Kentucky, Missouri, Nebraska, Rhode Island, Wisconsin.	1,951,488
clay loam [g]	Indiana, Iowa, Michigan, Ohio, Washington, Wisconsin.	1,831,818
Total		7,422,760

[a] Mapped as Marshall gravel in Pontiac area, Michigan.
[b] The soil mapped as Miami gravelly loam in the Big Flats area and Syracuse area, New York, is the Dunkirk gravelly loam.
[c] The soil mapped as Miami sandy loam in the Grand Forks area, North Dakota, is the Clyde fine sandy loam; in the Montgomery County area, Ohio, is Wabash sandy loam; and in Posey County area, Indiana, is Wabash fine sandy loam.
[d] The soil mapped as Miami fine sandy loam in Posey County, Ind., and Union County, Ky., is Waverly fine sandy loam; in the Boonville area, Indiana, is the Norfolk fine sandy loam; in the Lyons and Syracuse areas, New York, is Dunkirk fine sandy loam; and in St. Claire County, Ill., is Memphis silt loam.
[e] The Miami loam in the Auburn, Lyons, and Syracuse areas, New York; the Columbus, Coshocton, Montgomery, Toledo, and Westerville areas, Ohio; the Fargo and Grand Forks areas, North Dakota; the Marshall, Minnesota, and Pontiac areas, Michigan; and the Viroqua area, Wisconsin, is Wabash loam. The soil mapped as Miami loam in Tazewell County, Ill., is Sioux loam, and that mapped as Miami loam in the Janesville area, Wisconsin, is the Sioux sandy loam.
[f] The soil mapped as Miami silt loam in the Syracuse area, New York, is Dunkirk silt loam, and that mapped as Miami silt loam in Clinton and St. Claire counties, Ill., is Marshall silt loam.
[g] The soil mapped as Miami clay loam in Toledo area, Ohio, is Dunkirk clay loam, and that mapped as Miami clay loam in the Stuttgart area, Arkansas, is Crowley silt loam.

Volusia series.

The soils of the Volusia series are derived from the feeble glaciation of the shales and sandstones of the Devonian and the Upper Carboniferous rocks of eastern Ohio, southern New York, and northern Pennsylvania. In all cases the underlying shales and sandstones have given rise to a large proportion of the soil material, and this has been modified to a varying degree by glacial material brought in from other regions.

Topographically the soils of the Volusia series occupy the upland portion of the plateau country which slopes north and west from the Allegheny Mountains. In the higher, more easterly portions of the glaciated section of the plateau deep preglacial erosion has cut the upland into blocky rounded or flat-topped hills separated by deep, steep-sided gorges. Farther west, where the elevations are less, this topographic feature is not so pronounced, and the series occupies rolling hills divided by deep valleys. Under cultivation all of the soils of the series are well adapted to the production of potatoes, timothy, and small grains, particularly oats and buckwheat. At lower elevations wheat and corn give good yields.

The Volusia loam and silt loam are the most important types of the series. The surface of the loam is less rolling than that of the silt loam. The former is well adapted to the production of potatoes, grass, oats, buckwheat, and corn in less elevated portions. Apples are also grown to advantage throughout a considerable part of its extent. The silt loam occupies rolling and hilly land and is frequently interrupted or bordered by steep slopes not suited to agricultural purposes. Where properly cultivated it is a good soil for timothy and small grain. Owing to the hilly character of the country, transportation by wagon is rather difficult, and the type should be used more for the raising of cattle and sheep, in order to utilize its known capabilities for the production of hay and oats, rather than for the growing of bulky grain products which must be hauled to market at considerable cost. The stony loam is rather above the average of the other members of the series for general farming. On well-drained areas, particularly on northern and northwestern slopes, apple orchards are highly successful. The gravelly loam and clay loam, while only of very limited occurrence, are good soils, the former being particularly adapted to apples and the latter to grasses. There are large areas of these soils which are not as highly developed as they should be or as they have been in the past. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Volusia series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Volusia stony loam	New York	12,352
gravelly loam	do	4,608
loam	New York, Ohio	464,674
silt loam	Indiana, New York, Ohio	569,984
clay loam	New York	5,952
Total		1,057,570

Miscellaneous soils of the glacial and loessial regions.

The Allis clay, which is a residual soil derived from the weathering of light-colored shales, is adapted to general farm crops and to dairy farming. Corn, oats, and hay are the principal crops grown, and all do well.

The Allis shale loam is closely related to the clay, but contains a large percentage of shale fragments. The type occupies steep slopes and is well adapted to grains and grasses. Owing, however, to its rough topography it is probably best used as pasture.

The Barnum loam is closely associated with the stony loam. The surface is rolling and natural drainage is usually good. It is derived from the "red till," and is adapted to hay, oats, and wheat.

The Barnum stony loam has a rolling and hilly surface and constitutes a part of what is known as the "red till." Where not too rough and stony it is adapted to oats, hay, and wheat.

The Bellingham silt loam occupies small, poorly drained basins. It is used chiefly for growing hay, but when underdrained it produces good yields of vegetables. Both clover and timothy do well on this type.

The Bernardstown loam occurs in very broken and hilly areas and outcrops of the underlying argillaceous rocks are very common. It is very productive, being particularly fine for grass and grazing, and also produces excellent crops of corn, oats, and rye.

The topography of the Bloomfield sandy loam varies from gently rolling hills to hummocks consisting of small mounds and narrow ridges of low relief. It produces fairly good crops of corn, wheat, rye, and clover, while truck crops and also tree fruits, such as cherries, apples, and peaches, do well.

The Cassadaga sand occurs usually in upland valleys and is commonly wooded. The soil is inclined to be wet and marshy and is in need of drainage. Very little of this type is under cultivation and it has at present little agricultural value. If it were cleared and drained it would probably be suited to grass.

Custer loam produces fair yields of oats and hay, and when well cultivated the better drained areas produce good yields of potatoes and other vegetables. The average yield of clover is estimated at 2 to 3 tons, and of oats at about 40 to 50 bushels per acre. When drained its agricultural value will be greatly increased.

The Custer silt loam is a very productive soil. The principal crops are oats and hay, the former averaging 50 to 60 bushels per acre, although as high as 80 or 100 bushels have been secured. Timothy and clover do well, producing 2 to 3 tons, but 3½ to 4 tons is not an uncommon yield. Canadian field peas are successfully grown, yielding 40 to 50 bushels per acre. Irish potatoes do well on well-drained land, often yielding 300 to 400 bushels. Tree fruits and small fruits, and beets, peas, cabbage, and other truck make profitable yields.

The Dover fine sandy loam is a light, friable soil, and were it not for the rough surface and outcrops of the underlying dolomite would be easy to cultivate. The type is quite productive, but is devoted largely to pasture.

The Dover loam is considered a strong soil for all general farm crops grown in the section where it occurs, and is especially prized for pasture. It is also fairly well adapted to fruit.

The Dutchess silt loam is practically all cleared and cultivated, being used principally for pasture and hay. Fruits, especially apples, are also grown with success where position and climatic conditions are favorable.

The surface of the Dutchess slate loam is rather broken and hilly, and outcrops of the underlying slate are frequent. It is largely devoted to grass and makes good hay and pasture. In general it is considered a thin soil, requiring fertilization to give the best yields.

Except where fruit is grown, the Dutchess stony loam is not generally desired as farming land because of its rough surface. It seems peculiarly adapted to the growing of violets, and supplies the soil for the greenhouses about Rhinebeck, N. Y. Grass does well and the type makes good pasturage.

The Gloucester loam, which has resulted from the feeble glaciation of mica schists, is considered an especially strong soil for grass, and large crops of timothy, redtop, and clover hay are harvested. The sections where it occurs are therefore largely devoted to dairying.

The Gloucester stony loam constitutes a considerable proportion of the glacial soils of New England. Very little of it is cleared and under cultivation, and it is covered for the most part with a stunted growth of chestnut oak, white birch, and undergrowth. Some corn and potatoes are produced, but only light yields are obtained. In Merrimack County, N. H., it is used to considerable extent for the production of hay and for pasture. The type as a whole is best suited to forestry and pasture, though in some places orcharding should be profitable.

The Gloucester stony sandy loam occurs throughout a large portion of New England and consists of glacial material composed principally of crystalline rocks. The type occupies the tops and slopes of hills. It is not a strong soil, but is fairly well adapted to the production of corn, oats, and grass. Apples also do well.

Owing to the stiff, tenacious character of the soil and its location on the steep sides of bluffs, the Hobart clay has but little value except as a sheep and cattle pasture.

The Holyoke stony loam occupies rough and mountainous country and is devoted chiefly to pasture, though it is used to some extent for fruit.

The Judson loam is an unimportant type occurring as a colluvial deposit along the foot of the uplands. It is admirably suited to fruit, especially apples. Good crops of corn, wheat, cabbage, and potatoes are raised, but only a small part of the type is at present under cultivation.

The Lexington silt loam is derived from the loess and closely resembles the Memphis silt loam, but the deposit of loess is very thin, the surface is more hilly and broken, and the soil is in places modified by the underlying Lafayette formation. The soil is adapted to corn, cotton, forage crops, vegetables, and strawberries.

The Lynden gravelly loam is covered by a heavy growth of virgin forest. The soil seems especially adapted to the growing of fruits, and much of the cleared land is used for their production. Apples, pears, plums, prunes, etc., do exceeding well and the acreage devoted to orchards is annually increasing. Very fair yields of Irish potatoes have been secured.

The Lynden sandy loam is still covered by a heavy timber growth. When properly cultivated it produces profitable yields of potatoes, fruits, and small fruits. Both clover and timothy have been successful. The soil will grow early vegetables, returning large yields. Field and garden peas produce 50 to 60 bushels per acre. Orchards flourish, particularly the apple, pear, plum, prune, and cherry trees.

Lynden silt loam is well adapted to fruit growing. Large yields of apples, pears, plums, prunes, and cherries are obtained, and the fruit is of fine quality. Raspberries and blackberries are grown to a limited extent and do well; strawberries do exceedingly well. Clover and timothy make good yields of fair quality hay, and Irish potatoes return 200 bushels per acre. Vegetables also prove profitable.

The Lynden fine sandy loam supports a heavy forest of fir and cedar, and a dense undergrowth. Oats yield 50 bushels, and Irish potatoes 200 bushels on an average per acre. Clover and timothy have proved successful on a limited acreage. Cabbage, cauliflower, carrots, pumpkins, garden peas, cucumbers, and other vegetables do well. Canadian field peas yield from 50 to 60 bushels per acre. Many small orchards of various kinds of fruit produce large yields.

The Madison loam frequently has poor drainage, but is a good soil for corn, hay, and truck crops, especially cabbage, tomatoes, and berries.

Madeland includes a small area where fills have been made.

A large proportion of southern Illinois is occupied by Marion silt loam. The type occupies level prarie land and is characterized by hard silty clay subsoil locally known as "hardpan." It is low in organic matter and this combined with the impervious nature of the subsoil causes crops to suffer in wet as well as dry years. Wheat, corn, and grass are the principal crops, but the average yields are considerably lower than upon the black prairie soils. It seems especially well adapted to apples, and many large orchards have been planted. Strawberries also do well.

The Memphis silt loam is one of the most extensive soil types of the United States. It is derived from the deposit of loess which borders the Mississippi throughout a large part of its course. It occupies the uplands and is subject to serious erosion, especially in southern areas. Good yields of cotton, corn, wheat, oats, hay, and potatoes are secured in different localities. In the northern areas the soil is good for fruits and vegetables.

The topography of the Portage sandy loam varies from gently rolling to nearly level, the latter areas being poorly drained. It is adapted to general farm crops, yielding 1½ tons of hay, 100 bushels of potatoes, 30 bushels of corn, 40 bushels of oats, and 10 to 15 bushels of rye per acre. It is also well suited to fruits and vegetables.

The Portage silt loam has been studied in the survey of Portage County, Wis. The type occupies level or slightly undulating areas, is rather poorly drained, and sometimes marshy. It is well adapted to general farm crops, small fruits, and vegetables.

The Portage stony sandy loam has considerable quantities of bowlders, principally of granite, scattered over the surface. The drainage is rather poor and the type is used only for pasture.

The Rhinebeck loam is an easy soil to till and is fairly productive, making good crops of corn, cabbage, and hay. It is of local occurrence and only small areas have been encountered.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The Safford silt loam is associated with the Lexington silt loam and represents a thin deposit of loess over heavy clays of Cretaceous age. The soil is adapted to corn, cotton, wheat, and hay. It has a rolling to hilly topography and washes badly if not properly managed. The surface soil is loose and rather incoherent when dry, and is easily cultivated.

The Scottsburg silt loam is best adapted to tomatoes and other vegetables, to small fruits, and to all early maturing crops. It is low in organic matter, but by the addition of humus and the adoption of suitable crop rotations general farm crops may be made to do well.

The Shelby loam occupies steep slopes adjacent to water courses in northeastern Missouri and southern Iowa. It is much less productive than the Shelby silt loam. It is poorly adapted to wheat and corn and is used almost exclusively for pasture.

The Shelby sand occurs as gently rolling upland and is adapted to truck, small fruit, peaches, and wrapper leaf tobacco. It is very limited in extent and of little agricultural importance.

The Shelby silt loam resembles both the Marshall and Marion silt loam. It differs from the former in having a heavy impervious subsoil and from the latter in the darker color of the surface soil. It occupies the level to gently rolling prairies in northeastern Missouri and southeastern Iowa. The principal crops are hay, corn, oats, and wheat, and the production of apples is also of some importance. The impervious character of the subsoil causes crops to suffer during drought and it is a less desirable soil than the Marshall silt loam.

Whatcom silt loam supports a heavy growth of fir, cedar, and hemlock. It is very productive and a good seed bed is easily formed. It is well adapted to strawberries, Irish potatoes, vegetables, and, of the fruits, to apples, pears, plums, prunes, and cherries. Clover and timothy do well, giving 3 to 4 tons of hay to the acre. Oats and barley produce very fair yields, and peas, cabbage, and garden truck are grown with profit.

The Whatcom stony loam is a rough mountainous soil. Very little of it is cleared and under cultivation, and only a limited acreage is suited for agriculture.

The Wheatland sand is of limited occurrence and has little agricultural value, but is best adapted to pasture and grazing.

The Wheatland sandy loam is an upland soil of good drainage. It is fairly well adapted to wheat, oats, barley, flax, and corn.

The Williams loam may be considered as the semiarid equivalent of the Marshall loam. It occupies a large proportion of the uplands in northwestern North Dakota and northeastern Montana. It is a strong soil and is devoted to wheat and flax and to a lesser extent to oats, barley, rye, and millet. If the moisture conditions were more favorable this soil would be very highly esteemed for agricultural purposes.

The Williams stony loam occurs in the glaciated uplands of the semiarid region. Owing to its rolling topography and stony character it is devoted to pasture.

Area and distribution of the miscellaneous soils of the glacial and loessial regions.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Allis clay	New York	2,304
Allis shale loam	do	2,368
Barnum loam	Minnesota	2,496
Barnum stony loam	do	8,704
Bellingham silt loam	Washington	13,056
Bernardstown loam	Massachusetts	16,064
Bloomfield sandy loam	Indiana	10,944
Cassadaga sand	New York	1,660
Custer loam	Washington	8,128
Custer silt loam	do	8,960
Dover fine sandy loam	New York	8,512
Dover loam	do	28,800
Dutchess stony loam	do	51,776
Dutchess slate loam	do	94,144
Dutchess silt loam	do	117,184
Gloucester loam	do	10,752
Gloucester stony loam	New Hampshire, New York, Rhode Island	413,568
Gloucester stony sandy loam	New Hampshire	67,904
Hobart clay	North Dakota	6,208
Holyoke stony loam	Connecticut, Massachusetts	196,818
Judson loam	Minnesota	3,968
Lexington silt loam	Tennessee	342,272
Lynden gravelly loam	Washington	16,640
Lynden sandy loam	do	30,208
Lynden fine sandy loam	do	5,696
Lynden silt loam	do	16,256
Madison loam	Indiana	2,240
Madeland	New York	1,024
Marion silt loam	Illinois, Missouri	695,040
Memphis silt loam[a]	Illinois, Kentucky, Louisiana, Mississippi, Missouri, Tennessee.	1,643,002

[a] The soil mapped as Memphis silt loam in Posey County, Ind., and Union County, Ky., is Lintonia loam, and mapped as Miami fine sandy loam in St. Clair County, Ill., is the Memphis silt loam.

Area and distribution of the miscellaneous soils of the glacial and loessial regions—Continued.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Portage sandy loam	Wisconsin	9,792
Portage silt loam	....do	22,656
Portage stony sandy loam	....do	11,392
Rhinebeck loam	New York	1,088
Rock outcrop, Rough stony land, Steep broken land, Rough broken land, Riverwash.[a]	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, New Hampshire, New York, Vermont, Washington, Wisconsin.	649,920
Safford silt loam	Tennessee	28,544
Scottsburg silt loam	Indiana	37,184
Shelby loam	Missouri	410,368
Shelby sand	....do	448
Shelby silt loam	....do	402,112
Whatcom stony loam	Washington	28,608
Whatcom silt loam	....do	62,592
Wheatland sand	North Dakota	29,504
Wheatland sandy loam	....do	16,768
Williams loam	....do	272,256
Williams stony loam	....do	69,888
Total		5,879,816

[a] Mapped as the Clarksville stony loam in the Dubuque area, Iowa.

GLACIAL LAKE AND RIVER TERRACES.

Another important group of soils occurs in the glacial region, principally as terraces around lakes, or along streams, or as deposits in areas which were formerly covered by water. At the close of the Glacial epoch the lakes in this part of the United States were not only more numerous, but the waters of those which remain reached a higher level and covered areas that are now far above their present shorelines. In some cases several distinct terraces, each one marked by an old shoreline, are easily discernible, and represent successive stages in the lowering of the water level. Their elevation above the lake varies from a few feet to more than 200 feet. The surface of each terrace is usually rolling to level, with a gradual slope toward the lake, but sometimes areas of a rough and broken character occur. The streams which cross these terraces have frequently by their cutting produced deep, steep-sided valleys, especially near the lakes.

The soils of this group vary from typical beach gravels to offshore deposits of heavy clays. The material from which they are derived consists of glacial débris reworked and redeposited in the lakes or along streams. While this glacial material is made up of rocks of widely varying origin, a large proportion of it often consists of the country rock. In the eastern part of the Great Lake region the percentage of sandstone and shale fragments is usually very high, while in the western part more of the igneous rocks are present. This fact, together with differences in drainage conditions, has given rise to several series of soils. The aggregate area of the soils surveyed in this soil province is 5,091,882 acres.

Clyde series.

The soils of the Clyde series consist of reworked glacial material containing a large percentage of organic matter. The surface soil of this series is of a dark-brown to black color, underlain by gray, drab, or mottled yellow subsoils. The dark color of the surface soil, which is the most distinctive characteristic of this series, is due to the accumulation of a large percentage of organic matter under swampy conditions. The soils of the Clyde series may be considered as intermediate between the light-colored Dunkirk soils on the one hand and the Muck and Peat areas on the other. They almost always require drainage, and when this is provided they are very productive.

The loam is the most important member of the series, both in extent and in agricultural value. In Michigan it constitutes the most highly prized soil for sugar beets, giving the most uniform and satisfactory results. When well drained it gives excellent yields of corn, wheat, oats, and hay. Cabbage and canning crops also prove profitable. Much of the type is undeveloped for lack of drainage. Around Racine, Wis., the clay loam has been extensively used for cabbage and also for corn, wheat, and hay. The clay occupies poorly drained areas, and is not much used for agriculture. It is a strong soil, and when drained is well adapted to sugar beets, as well as general farm crops. The fine sandy loam is a very desirable truck soil and is admirably adapted to cabbage, tomatoes, peas, beans, cucumbers, and potatoes. In Michigan it is used to some extent for sugar beets, but is not considered as desirable as the loam or sandy loam. It is not a good peach soil, but where properly drained apples and pears do fairly well. For general farming the sandy loam ranks next to the loam, and this type, together with the stony sandy loam, are devoted largely to this purpose. The gravelly sand and fine sand give fair yields of grain crops, but are best suited to trucking and small fruits, the fine sand being especially adapted to strawberries. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Clyde series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Clyde stony sandy loam	Michigan	8,000
gravelly sand	do	24,656
gravelly sandy loam	Washington	5,952
sand	Michigan	67,400
fine sand	Indiana, New York	61,376
sandy loam	Indiana, Michigan, Washington	111,808
fine sandy loam [a]	Michigan, New York, North Dakota, Wisconsin	141,824
loam	Indiana, Michigan, New York, North Dakota, Washington.	538,796
silt loam	Michigan	3,904
clay loam	Wisconsin	12,224
clay [b]	Indiana, Michigan, New York, North Dakota, Ohio.	235,392
Total		1,211,332

[a] Mapped as Miami sandy loam in the Grand Forks area, North Dakota.
[b] Mapped as Miami black clay loam in Toledo area, Ohio.

Dunkirk series.

The Dunkirk series is an important member of the glacial terrace group of soils. The soils have been formed by the reworking of glacial material derived from limestone, sandstone, and shale. This series embraces light-colored surface soils with drab, gray, and mottled yellow subsoils and occurs principally in the eastern part of the Great Lakes region. The soils are not as productive as those of the Clyde series, but some of them are well adapted to special crops.

The loam is a very important member of the Dunkirk series. It is a good general-purpose soil and is considered fine for fruit, especially apples, pears, plums, and cherries. The color, flavor, and keeping quality of the former two are better than upon either the lighter or heavier soils. The silt loam is easily tilled and produces good yields of general farm crops, besides berries and fruits. Upon the clay loam, clay, and stony clay wheat and grass do well, while near the Lakes grapes are grown with much success. The sandy loam and fine sandy loam are quite extensively used for trucking and small fruits, and in Tompkins County, N. Y., furnish a good example of a case where the special adaptation of a soil to particular crops has been utilized. They are a little light in texture for general farming. Peaches on the fine sandy loam produce a strong, thrifty tree and a good flavored fruit. Grapes are also successfully grown. The fine sand is not suited to general farming, but for early truck and other crops requiring a light sandy soil it has proved valuable. Peaches, apples, and pears are grown, but the trees are usually short lived and subject to disease, while the fruit is of inferior quality. The gravel is of little value except for the production of grapes. The gravelly sandy loam gives moderate yields of ordinary farm crops and should be used as a fruit, potato, and corn soil. The gravelly loam gives large crops of corn and fair crops of hay and oats, while potatoes, beans, and pears also do well. The acreage of the types so far encountered is shown in the table on the following page.

Area and distribution of the soils of the Dunkirk series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Dunkirk stony clay	New York	35,072
shale loam [a]	do	14,592
gravel	New York, Ohio	7,720
gravelly sandy loam [b]	do	37,532
gravelly loam [c]	do	106,816
fine sand	New York	10,944
sandy loam	do	4,480
fine sandy loam [d]	New York, Ohio, Wisconsin	153,290
loam	New York, Ohio	147,712
silt loam [e]	New York	94,272
clay loam [f]	New York, Ohio	127,616
clay [g]	do	140,546
Total		880,592

[a] The soil mapped as Dunkirk shale loam in the Westfield area, New York, is the Dekalb clay.
[b] Mapped as Dunkirk gravelly loam in the Ashtabula area, Ohio, and Westfield area, New York.
[c] Mapped as Miami gravelly loam in the Big Flats and Syracuse areas, New York.
[d] Mapped as Miami fine sandy loam in the Lyons and Syracuse areas, New York. Mapped as Dunkirk sandy loam in the Ashtabula area, Ohio, and Westfield area, New York.
[e] Mapped as Miami silt loam in the Syracuse area, New York.
[f] Mapped as Miami clay loam in the Toledo area, Ohio.
[g] The areas mapped as Dunkirk clay in the Lyons and Syracuse areas, New York, are Alloway clay.

Fargo series.

The Fargo series occurs throughout the Red River Valley and in other old glacial lake beds in the same region. The soils have been formed by the reworking of glacial material and its deposition in glacial lakes. The soils are very black in color and contain a very large percentage of organic matter, in some cases enough to make the soil slightly mucky. There is also present, especially in the subsoil, a large percentage of lime. They rank among the most productive soils in the country.

The clay loam is the most extensive and one of the strongest types of soil in the Red River Valley. The surface is very level and artificial drainage is necessary, but when this is provided the soil is well adapted to wheat, oats, barley, and flax. Similar experiments with clover and alfalfa demonstrate that they can be grown successfully. About the same crops are grown upon the fine sandy loam as upon the clay loam, but owing to naturally better drainage the yields are more certain. Vegetables, which do well, are produced to a limited extent for local markets. Timothy is grown mainly for hay. The silt loam is probably the most desirable soil in the valley and is well suited to wheat, oats, barley, and flax, giving excellent yields of all these crops. This type has contributed most to the fame of the Red River Valley as a wheat-growing country. Vegetables and garden truck are grown with excellent results. The loam, naturally poorly drained, owing to its low, flat topography, is used largely for hay. It is a strong soil and where well drained produces good wheat, flax, and oats. The clay is a very heavy soil, locally called "gumbo." It is regarded as one of the most productive of soils, but it is rather difficult to get the seed in early enough in the spring and to keep the soil from baking after rains. Under the present imperfect condition of drainage these lands are held in low esteem for general farming. When seeded with brome grass or covered with natural prairie grass they are excellent for hay and pasture. A very large proportion of the sandy types is yet unbroken and utilized chiefly for the production of wild hay. When drained they are good soils for potatoes, small fruits, and corn. Where earliness of maturity is so important as in this latitude, the light texture makes them better suited to the latter crops than the heavier soils. Wheat, flax, and wild hay are the chief crops at present.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Fargo series.

Soil names.	States in which each type has been found.	Total area.
		Acres.
Fargo sand	North Dakota	22,016
fine sand	do	19,904
loam	do	20,800
fine sandy loam	Minnesota, North Dakota	133,504
silt loam	do	27,072
clay loam	do	344,576
clay	do	70,336
Total		638,208

Hudson series.

The Hudson series consists of light-brown to yellowish-brown soils, underlain by drab to yellowish subsoils. The latter are generally lighter in texture than the soils of the Vergennes series. They occur as glacial lake terraces, composed principally of wash from glaciated slate uplands, and are generally quite desirable soils.

The sandy loam is easy to work, but very little is cultivated. It is particularly well adapted to truck and small fruits, and produces also fair yields of the general farm crops. The fine sandy loam is also well suited to trucking and in favorable localities is highly esteemed for fruits and vegetables. The gravelly subsoil of the loam gives it good drainage, and it grows good thrifty apples and produces small fruits, truck crops, especially heavy truck, such as potatoes, tomatoes, and root crops. Away from the immediate vicinity of the villages mixed farming is practiced, dairying being carried on in connection with general farming and fruit growing. The heavy character and impervious nature of the subsoil make the clay loam cold and wet. It is therefore not very desirable for general farming, although well suited to grass. The areas of the several types so far encountered are as follows:

Area and distribution of the soils of the Hudson series.

Soil name.	State in which each type has been found	Total area.
		Acres.
Hudson clay loam	New York	9,984
fine sandy loam	do	6,400
loam	do	3,904
sandy loam	do	1,856
Total		22,144

Merrimac series.

The Merrimac series is found almost entirely in the New England States and constitutes the glacial terraces which occur along nearly all the streams of this section. The material consists principally of crystalline rocks which were ground up by the ice, reworked by water, and deposited during the close of the glacial period. The soils are brown in color and are underlain by sand and gravel.

In New England and eastern New York there occurs along the streams on high terraces a series of soils to which the name Merrimac has been given. From their composition and structure they are usually leachy soils, and this is specially the case with the coarser soils. The coarse sand and gravelly sandy loam are of low crop producing value, but with fertilization they produce garden crops. The sand, though not cultivated to any extent, is a soil that in its locality would be valuable for trucking. The gravelly loam has a wider crop adaptation, producing the general farm crops and in eastern New York apples. The fruit colors especially well, but matures so early that the keeping quality is not as good as fruit produced on later soils. The loam and sandy loam are strong grass and corn soils. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Merrimac series.

Soil names.	States in which each type has been found.	Total area.
		Acres.
Merrimac coarse sand[a]	Connecticut, Massachusetts, New Hampshire, Rhode Island.	112,136
coarse sandy loam[b]	Connecticut, Massachusetts, Rhode Island	110,720
gravelly sandy loam	Connecticut, Massachusetts, New Hampshire, New York.	119,124
gravelly loam	New York	41,216
sandy loam	Connecticut, Massachusetts	95,304
sand	New Hampshire	26,560
loam	New York	1,600
Total		506,660

[a] Mapped as Norfolk coarse sand in Rhode Island.
[b] Mapped as Norfolk coarse sandy loam in the Connecticut Valley area, Connecticut-Massachusetts.

Sioux series.

The Sioux series comprises the dark-brown to black terrace soils characterized and distinguished from the Wabash series by a bed of gravel usually within 3 feet of the surface. This gravel bed has a very marked effect upon the drainage of the soils and causes crops to suffer in times of drought, except in areas where the gravel is several feet below the surface. This series occurs as terraces along streams, and is practically confined to the glacial regions.

The sandy loam is well suited to the production of early short-seasoned crops. The fine sandy loam is less droughty than the sandy loam, and produces good yields of corn, wheat, oats, barley, alfalfa, and sugar beets. The sand and gravelly sandy loam give uncertain yields on account of excessive drainage. The loam is admirably adapted to the growing of crops for canning purposes, although largely used for general farming. The silt loam is an exceedingly fertile soil, very highly esteemed for corn and small grain. The clay is also a strong soil for general farming. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Sioux series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Sioux gravelly loam	North Dakota	30,400
gravelly sandy loam	Minnesota	24,448
sand	Wisconsin	19,520
sandy loam[a]	Illinois, Indiana, Iowa, Missouri, Nebraska, South Dakota, Wisconsin.	198,848
fine sandy loam	Nebraska, North Dakota	65,984
loam[b]	Illinois, Indiana, North Dakota	49,152
silt loam	Illinois, Indiana, Wisconsin	32,826
clay	North Dakota	2,432
Total		423,610

[a] Mapped as Miami loam in the Janesville area, Wisconsin.
[b] Mapped as Miami loam in Tazewell County, Ill.

Superior series.

Another member of the glacial lake group of soils is found around Lake Superior. The material here consists of a red clay, over which in some places sands and sandy loams have later been deposited or washed from higher lying areas, giving rise to soils of a light and more sandy character. There has thus been formed the Superior series of soils, characterized by the red color of the subsoils.

The sandy loam of the Superior series is a warm soil, easily tilled, and adapted to clover, timothy, potatoes, and small fruits. The topography of the silt loam is so uneven as to make this type of low agricultural value. The clay is a heavy soil, being rather difficult to cultivate, but yields good crops of timothy and clover, as well as potatoes, peas, and beets. None of the soils of the series have been extensively developed.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Superior series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Superior sandy loam	Wisconsin	14,208
silt loam	Minnesota	16,192
clay	Michigan, Minnesota, Wisconsin	198,784
Total		229,184

Vergennes series.

The Vergennes series occurs on the terraces surrounding Lake Champlain. It consists of deep-water sediments known as the Champlain clays, deposited in postglacial times over glacial drift during a period of submergence. Since the uplift these clays have been more or less modified by stream action and colluvial wash from soils of the surrounding highlands derived from the underlying geological formations, usually sandstone, shale, and limestone, and in limited areas by wash from glacial drift soils. The series is characterized by brown, yellowish, or gray soils, underlain by drab to blue or light-gray clay subsoils at varying depths. The surface is level to gently rolling, and for the most part artificial drainage is necessary.

The clay is the most extensive, as well as the most important, of the Vergennes soils. It is a heavy soil—one which requires careful and painstaking cultivation to secure the best results. Its heavy texture makes it admirably adapted to the production of hay, and this constitutes the leading crop. It is not an ideal corn soil, but profitable yields of this grain, as well as of oats and barley, are secured. The black clay requires drainage, and were this done it would be the best corn soil of this section. Good yields of hay are cut from the better drained portions, while the more poorly drained portions are used only for pasturage. The best apple orchards in the Champlain Valley are found upon this type and the fruit produced is of high quality. Soils better adapted to tilled crops militate against the extensive cultivation of this type, most of which is used as pasture or woodland. Certain of the more easily tilled portions are highly esteemed for potatoes. The fine sand is best adapted to truck crops and small fruits, though corn, oats, and hay are grown with fair success; corn, clover, and late truck do well on the sandy loam, while the loam is desirable for corn, hay, oats, and barley. The gravelly loam is well adapted to potatoes. The acreage of the types so far encountered is given in the table on page 161.

Area and distribution of the soils of the Vergennes series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Vergennes stony loam	New York, Vermont	17,024
gravelly loam	do	3,968
fine sand	do	8,384
sandy loam	do	2,112
loam	do	4,352
black clay	Vermont	3,584
clay	New York, Vermont	129,984
Total		169,408

Miscellaneous soils of the glacial lake and river terraces.

The Bearden loam is closely related to the Sioux loam, but differs from it in that the gravel and sand are much farther below the surface. It is fairly level in topography, and nearly all of it is sufficiently well drained to produce good crops. At present the soil is devoted chiefly to small grains, flax, and wild hay, of which good yields are secured.

The Benoit loam is closely associated with the fine sandy loam, and like this type occurs as broad, shallow, poorly drained depressions between old beach lines. A few of the better drained areas are cultivated, but the soil as a whole is so poorly drained that it is used mainly for pasture land or hay meadows.

The Benoit fine sandy loam occupies low, basinlike depressions which occur between or adjacent to old beach lines. A large part of it is poorly drained and only a very small part is under cultivation. The greater proportion is used for hay meadows and as pasture.

On account of its compact nature and poor underdrainage the Elmwood loam, which occupies level terraces along the Connecticut River, has very little agricultural value at present.

The Enfield sandy loam represents the overlapping of sandy glacial lake deposits upon the glacial till. Some tobacco of fair quality is produced and medium yields of truck and grain are secured, but the soil is not well suited to the production of grass. The type is not of much agricultural importance.

The Marco clay loam is well adapted to grass, and heavy crops of clover and timothy are obtained. The type is rather poorly drained, but when drainage is provided it is a strong, fertile soil.

Owing to the level, stony nature of the Lockport clay the greater part of the type is devoted to pasture. It is best suited to grass, which fact has been generally recognized.

The McLeod sand consists of low, rounded dunes and ridges scattered over comparatively level sandy plains forming the bed of glacial Lake Agassiz. A large part of the type is used for pasture. Wheat, oats, barley, and flax are grown to a limited extent, but the yields are light.

The Manchester sandy loam is naturally a fertile soil, but the porous character of the subsoil renders it subject to drought. It is well adapted to peaches and fairly well to corn.

The Mankato loam is closely associated with the Mankato sandy loam and occupies a similar topographic position. The presence of the underlying rock near the surface causes it to suffer from drought during dry seasons. With favorable rainfall good crops of corn and wheat are secured.

The Mankato sand occurs as terraces along the Blue Earth River in Minnesota. On account of its good natural drainage the soil warms up early in the spring, making it well suited to the production of early vegetable and market-garden crops.

The Mankato sandy loam occurs as a river terrace, and the soil is underlain by rock at an average depth of 15 inches. This makes the type subject to drought. In seasons of heavy rainfall good crops are secured. Where the sand is deepest it is quite well adapted to the production of early vegetables.

The Marco fine sandy loam occupies nearly level to rolling areas and consists of old alluvial deposits modified by wind action. Wheat and corn are successfully grown and clover does exceptionally well. The slightly elevated portions of the type are very desirable sites for small fruit and truck gardens.

Muck and Peat are composed largely of organic matter in various stages of decay, the Muck representing an advanced stage of change in Peat areas. These soils are highly valued for their adaptation to special crops, such as celery, onions, peppermint, and cabbage.

The Newton fine sand occurs in level, poorly drained, marshy areas, and its chief use is for pasture.

The Podunk fine sandy loam occurs as terraces along the Connecticut and other rivers in New England. It is considered the most desirable soil in the Connecticut Valley for the production of the broadleaf tobacco. Corn and potatoes do well on this type, and it is regarded as a strong, safe, and productive soil.

The Podunk silt loam occupies level terraces along the streams throughout New England. It is best adapted to grass crops and gives large yields of hay.

The Saginaw sandy loam occupies an intermediate position between the Clyde sand and the Clyde loam. When properly drained the soil is fairly well adapted to truck, sugar beets, and corn, as well as to general crops.

Sandhill and Dunesand are deep sands of little agricultural value.

The Saugatuck sand is characterized by bands of sand cemented together by iron, forming a crust from a fraction of an inch to one or more inches in thickness. The type occupies slightly depressed areas and is best adapted to truck, peaches, and small fruits. Grain also does fairly well.

The Snohomish fine sandy loam occupies level to gently rolling river terraces in the vicinity of Puget Sound. The type is best adapted to late truck crops for canning purposes, and fruit also does well.

The Snohomish sand has a flat and fairly level surface, rising with a gentle incline from near sea level toward the inland. While the drainage is generally adequate on account of the easy fall and open texture, the soil is subject to drought. The soil is too light for general farming, but under suitable conditions might be utilized for the growing of early truck. It is also well adapted to early potatoes.

The Snohomish silt loam occupies level or gently rolling river terraces and is a good soil for general farming, as well as for the production of tree fruits.

On account of its close texture and poor drainage, the Suffield clay, found only in Connecticut and Massachusetts, has no value except as pasture land.

Swamp and Marsh consist of areas covered with water the greater part of the year and unfit for agriculture, except where drained and protected from tidal or fluvial overflow. When reclaimed much of this land will become very productive.

The Tonawanda loam is closely associated with the Dunkirk loam, but differs from it in having a lighter subsoil. The chief crops grown are corn, oats, hay, and potatoes, and during favorable seasons fair yields are produced.

The soil of the Warners loam, which is derived from marl, consists of 10 inches of mellow brown loam containing many calcareous nodules and a considerable proportion of marl. The subsoil is a gray or white marl, silty in character and of soft, unctuous feel, containing thin beds of muck at varying depths. The type produces good crops of corn and grass.

The Williston gravelly sandy loam occurs as terraces along streams in the semiarid glacial region. The gravelly character of the subsoil makes it subject to drought, but when moisture conditions are favorable it gives good crops of wheat, flax, and rye.

The Williston sandy loam is closely related to the type just described. It occurs as glacial terraces in the semiarid region. In seasons of average rainfall good crops of wheat and flax are secured.

The acreage of the types so far encountered is as follows:

Miscellaneous soils of the glacial lake and river terraces.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Bearden loam	North Dakota	3,584
Benoit loam	Minnesota	31,360
Benoit fine sandy loam	do	4,032
Elmwood loam	Connecticut, Massachusetts, Michigan	22,688
Enfield sandy loam	Connecticut, Massachusetts	46,462
Lockport clay	New York	6,656
McLeod sand	Minnesota, North Dakota	38,016
Manchester sandy loam	Connecticut, Massachusetts	44,160
Mankato loam	Minnesota	1,600
Mankato sand	do	4,032
Mankato sandy loam	do	2,816
Marco clay loam	Indiana	3,200
Marco fine sandy loam	do	3,392
Muck and Peat	Illinois, Indiana, Iowa, Michigan, New York, North Dakota, Ohio, Vermont, Washington, Wisconsin.	532,842
Newton fine sand	Indiana	5,888
Podunk fine sandy loam	Connecticut, Massachusetts, New Hampshire, New York.	30,404
Podunk silt loam	New Hampshire	960
Saginaw sandy loam	Michigan	14,272
Sandhill, Dunesand, and Coastal beach.	Michigan, Minnesota, North Dakota, Rhode Island, Wisconsin.	26,234
Saugatuck sand	Michigan	24,120
Snohomish fine sandy loam	Washington	9,728
Snohomish sand	do	21,504
Snohomish silt loam	do	16,192
Suffield clay	Connecticut, Massachusetts	23,610
Swamp, Tidal swamp and marsh	Indiana, Michigan, New York, Rhode Island, Vermont, Washington.	62,080
Tonawanda loam	New York	15,168
Warners loam	do	128
Williston gravelly sandy loam	North Dakota	12,352
Williston sandy loam	do	3,584
Total		1,010,744

RESIDUAL SOILS OF THE WESTERN PRAIRIE REGION.

This region consists of the nonglacial part of the prairie plains bounded on the north by the Missouri River, the southern limit of glaciers, and extending southward through Texas to the Rio Grande. On the west it merges into the Plateau region at very near the 2,000-foot contour, and on the east is limited by the Gulf Coastal Plain and the Ozark Plateau. Its surface is gently rolling, with occasional low hills, and is cut by numerous stream channels. The rocks are of Carboniferous age and consist of sandstones, shales, and limestones more or less interbedded. These rocks give rise to three series of soils, viz, Oswego, Crawford, and Vernon, together with a number of miscellaneous soils. In Kansas and Texas these soils are in some instances more or less modified by the admixture of gravel and sand from Tertiary deposits brought down from the higher areas farther west occupied by crystalline rocks.

The aggregate area of the soils surveyed in this province is 1,825,850 acres.

Crawford series.

This series includes residual limestone soils of the prairie regions, characterized by dark-brown to reddish-brown surface soils and reddish-brown to red subsoils. While derived from limestones, these soils usually contain only a small percentage of lime, differing very materially in this respect from the soils of the Houston series, occurring in the Cretaceous black prairies of the Coastal Plain. They are productive and well adapted to general farming.

The gravelly loam occurs in small bodies on ridges and hilltops, and on account of the gravelly surface and the too freely drained, leachy nature of the subsoil this type is too droughty for agricultural purposes, except in occasional wet seasons, when corn gives fair yields. The type is on the whole best adapted to stock raising, though small fruits may be found to do well in favored locations. The Crawford stony clay is a shallow, excessively stony soil, in general too rough and broken in topography for crops requiring much cultivation. It is well watered by numerous small streams, however, and produces a good growth of grass, making it a good grazing type for cattle, sheep, and goats. Grapes and small fruits do well. The texture of the loam makes it easy to cultivate, and it can be worked very shortly after rain without impairing the naturally good mechanical condition. The type is well suited to the cultivation of cotton, corn, and fruits and also produces very fair yields of wheat and oats. Several small orchards of peaches and plums produce very profitable crops, and fruit growing bids fair to become an important industry. Vegetables are successfully grown for home use and on a small scale for local markets. The silt loam occupies level to rolling prairies, and is well drained, with the exception of level and depressed areas. This soil is best adapted to corn; but all general farm crops, as well as fruits and vegetables, do well on this type. It is a strong, fertile soil well adapted to general farming. The clay is a heavier soil and more difficult to cultivate than the silt loam. It is, however, a strong soil, well adapted to wheat; while cotton, corn, alfalfa, clover, and timothy do well. The silt clay is probably the most valuable soil of the series and nearly all of it is under cultivation. It has been found along the foot of the escarpment extending from Austin to San Antonio, Tex. It is the most desirable truck soil in this section, and considerable areas are irrigated and planted to onions, which constitute the principal crop on irrigated areas. It is also an excellent soil for general farming and produces large yields of corn, cotton, oats, peanuts, and potatoes. Alfalfa also does well, and as many as nine cuttings, with an average of three-fourths of a ton per acre for each cutting, have been secured on an irrigated field.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Crawford series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Crawford stony clay	Texas	119,104
gravelly loam	Kansas	5,165
loam	Texas	6,784
silt loam	Kansas	211,559
silt clay	Texas	18,048
clay	Kansas, Texas	180,864
Total		541,524

Oswego series.

The Oswego series includes the light-colored soils of the prairie region formed from the weathering of interbedded layers of sandstone and shale, as distinguished from the Crawford series, which is derived from limestones. The surface soils are light to dark gray in color, while the subsoils are dark drab to yellow. The soils of the Oswego series are less productive than those of the Crawford series.

The Oswego fine sandy loam is of a light, sandy character and warms up early in the spring, permitting the planting of crops considerably earlier than upon the soils of heavier texture. In relatively wet seasons it is a good general-purpose soil, though yields are only fair. It is probably best adapted to corn, oats, and potatoes, being too light for wheat. Where located near enough to markets truck and fruit crops could be profitably grown. The silt loam of this series is a well-drained, moderately fertile soil, subject in some sections of Kansas to considerable erosion. On account of the close texture of the soil and heavy character of the subsoil it requires careful cultivation to preserve proper tilth. The areas which have been developed show the soil to be best adapted to wheat, with oats and corn second in importance.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Oswego series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Oswego fine sandy loam	Kansas	25,293
silt loam [a]	do	462,848
Total		488,141

[a] The soil mapped as Oswego silt loam in the Parsons area, Kansas, is the Neosho silt loam.

Vernon series.

The Vernon series includes the upland sands, loams, and clays derived from the weathering of the Permian Red Beds. The surface soils are gray and brown, while the subsoils are brown to red. This series occurs in the prairie regions of northern Texas and in Oklahoma. The soils are productive and well adapted to general farm crops.

The Vernon silt loam is the most important of the Vernon soils, both in extent and in agricultural importance. It occupies level and gently rolling prairie uplands and is a fine soil for general farming. A very large percentage of it is under cultivation, while the remainder is in prairie grasses, which are cut for hay. Wheat, oats, and corn are the crops most extensively grown. Cotton makes a good growth, but matures late, yielding from one-half bale to 1 bale per acre. Alfalfa and castor beans are also raised on this soil. Another important agricultural type of this series is the fine sandy loam. Oats, wheat, Kafir corn, and sorghum are among the principal crops. Cotton yields from one-third to three-fourths of a bale per acre. Peaches are grown commercially on this soil, and where properly located and cared for the orchards do excellently. In a limited way grapes are found. This soil also makes fine pasture. Owing to the lightness of the sand of this series, it is difficult to get a stand of any crop, and therefore farming on this soil should not be attempted to any great extent. Cotton and corn are the principal crops grown, though apples and peaches also do well when the trees once get started. The fine sand type is undesirable for agricultural purposes and cotton and corn yield only small crops. Peaches are grown in a limited way. The forested portions are used for pasture. The Vernon sandy loam is devoted to a variety of crops. Corn yields from 30 to 40 bushels per acre, oats from 30 to 60 bushels, Kafir corn from 20 to 40 bushels, and cotton from one-half bale to 1 bale per acre. The soil is too sandy to give satisfactory results to wheat except during favorable seasons. It is an excellent peach soil. This type is also good for truck, but at present only a small area is used for this purpose.

The greater part of the clay type of the Vernon series is used for pasture. Wheat, oats, and corn are the principal crops. This soil would be greatly improved by planting to Bermuda grass, which would afford good pasture for eight or nine months.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Vernon series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Vernon sand	Oklahoma, Texas	68,224
fine sand	Oklahoma	44,928
sandy loam	Oklahoma, Texas	40,576
fine sandy loam	do	167,296
silt loam[a]	do	190,464
clay	do	31,808
Total		543,296

[a] The soil mapped as Vernon silt loam in the Vernon area, Texas, is the Miller silt loam.

Miscellaneous residual soils of the western prairie region.

The Derby loam is a good soil for general agriculture. The chief crops are corn and wheat, the average yields being about 25 and 18 bushels, respectively.

The Gasconade silt loam is associated with the Clarksville silt loam, but is a more productive soil. Corn, wheat, timothy, and clover do well.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The Sedgwick black clay loam occupies flat or depressed areas in the upland prairies and is poorly drained. It is generally used only for pasture to wheat and corn.

The area of granite near Tishomingo, Okla., gives rise to the Tishomingo gravelly sandy loam. The more level areas form prairies covered with a growth of wild grasses, which furnish good grazing and a fair grade of wild hay. Corn and cotton do fairly well in a favorable season. Near the streams the type is covered with a scrub growth of timber, mostly oak, and is of low agricultural value.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the western prairie region.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Derby loam	Kansas	20,416
Gasconade silt loam	Arkansas, Missouri	16,320
Rock outcrop, Rough stony land[a]	Kansas, Oklahoma, Texas	180,889
Sedgwick black clay loam	Kansas	5,568
Tishomingo gravelly sandy loam	Oklahoma	29,696
Total		252,889

[a] Mapped as Clarksville stony loam in Wichita area, Kansas.

GREAT BASIN.

With the exception of one soil type recognized in the Laramie area, Wyoming, the soils in this group, so far as mapped, are confined to the Great Interior Basin region. They are derived from a great variety of rocks, and consist of colluvial soil of the mountain slopes, deep lacustrine and shore deposits of the Bonneville period, and of recent stream-valley sediments and river-delta deposits.

When not situated above or outside the limits of irrigation, or rendered unfit for cultivation by accumulation of alkali or seepage waters, they are of great agricultural importance, and are devoted mainly to the production of grains, sugar beets, alfalfa, stone or other tree fruits, and vegetables.

The aggregate area of the soils surveyed in this province is 1,005,600 acres.

Bingham series.

This series covers lower mountain slopes, upper valley slopes, and valley plains. It consists of colluvial mountain wash or of old alluvial deposits of torrential or intermittent streams, delta-cone deposits, or of a mixture of these materials. The soils are usually gravelly and generally treeless, except in the immediate vicinity of stream courses. The more elevated areas are frequently rough and hilly and marked by the presence of rock outcrop and bowlders. They are frequently cut by washes or intermittent stream channels and are well drained, except in the lower lying areas occupying depressions.

These soils are derived principally from eruptive, early sedimentary, and altered sedimentary rocks of all ages, and modified particularly by material derived from limestone, granites, shales, slates, etc. They occur as irregular and frequently extensive bodies, often lying above the limits of irrigation. When capable of irrigation, the soils are often well adapted to peaches and other fruits.

Of this series the gravelly loam has the highest agricultural value. It is chiefly adapted to fruit, such as apples, peaches, pears, cherries, plums, and apricots, and in some localities to raspberries and strawberries. It is also suitable for growing wheat, alfalfa, and grains, and in the vicinity of Salt Lake, Utah, in seasons of good rainfall, 20 bushels of wheat to the acre have been produced. In some localities this type is dry-farmed to wheat with good results. Vegetables may be grown on the gravelly loam, but not with the success of the other crops mentioned. The stony loam type of this series is situated above irrigation canals, and the soil is so filled with stones and bowlders that it is of little agricultural value. If, however, this land could be irrigated it would produce good fruits. It is at present used to some extent for mountain pasture. The loam needs irrigation, and when free from excessive amounts of alkali produces good alfalfa and grains. The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Bingham series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Bingham stony loam	Utah	62,222
gravelly loam [a]	do	132,112
loam	do	12,100
Total		206,434

[a] Mapped as Maricopa gravelly loam in the Provo area, Utah.

Jordan series.

The Jordan series consists of old stream sediments, probably deposited to a large extent in the waters of former lakes and modified by later shore and stream deposits. It thus consists of a mixture of stream and lacustrine sediments and occurs upon low, level or sloping valley plains covering the bed, benches, and shores of ancient Lake Bonneville. The soils are not subject to present extensive stream modification, and are treeless, except in the vicinity of streams or lakes. With the exception of the lower lying bodies the soils are usually well drained. The material is derived from a great variety of rocks of all ages, consisting of lavas, sandstones, shales, limestones, slates, quartzites, granites, etc. The soils occur as irregular and frequently as extensive areas, with the exception of the members of lighter texture, and are dark in color and agriculturally important, except where poorly drained and alkaline. They are generally devoted to grain, alfalfa, fruits, and truck crops.

Of the Jordan series, the sand is the leading truck and fruit soil, devoted extensively to the production of tomatoes, peaches, plums, etc. It is somewhat leachy in character, necessitating frequent irrigation, and is sometimes injured by the rise of the water table when not naturally well drained. The loam is the leading sugar-beet producing soil of this series, being followed by the clay loam in adaptation to this crop. These two soil types are adapted to irrigation and are easily cultivated, but sometimes subject to injury from accumulation of alkali or seepage water. The fine sand usually occurs in wind-blown areas and is relatively unimportant. The clay is often poorly drained and alkaline, but when well drained is adapted to alfalfa and grains.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Jordan series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Jordan sand[a]	Utah	32,168
fine sand[b]	do	4,920
fine sandy loam	do	48,620
loam[c]	do	95,700
clay loam	do	161,280
clay[d]	do	6,528
Total		349,216

[a] Mapped as Fresno sand in the Provo area and Weber County, Utah.
[b] Mapped as Jordan sand in Weber County and the Salt Lake area, Utah.
[c] The soil mapped as Jordan loam in the Provo and Bear River areas, Utah, is Jordan clay loam.
[d] The soil mapped as Jordan clay in the Salt Lake area, Utah, is Salt Lake clay loam.

Malade series.

This series occurs along valley troughs and in the vicinity of river flood plains, and consists of stream sediments of recent date or in process of formation. The soils occupy low or slightly elevated valley plains of smooth, nearly level surface, frequently marked by the presence of stream channels or sloughs. They are derived mainly from eruptive, early sedimentary, and altered sedimentary rocks, and occur as small narrow to broad, extensive areas. The soils are generally dark in color and are underlain by light-colored sands or sandy loams or by heavy red subsoils. The heavy members are compact. The areas are generally well drained.

The sandy loam is usually well drained and free from alkali, making a good soil for general farming. It is one of the best soils for sugar beets when under irrigation. The fine sand is also suitable for general farming purposes and for sugar beets when irrigated. Alfalfa forms the principal crop of the fine sandy loam, and in some localities orchards do well. It is also adapted to sugar beets. The loam, when free from alkali, produces fine sugar beets and grain, and when the water is not too near the surface it is suitable for fruits and alfalfa.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Malade series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Malade fine sand	Utah	6,080
sandy loam	do	3,264
fine sandy loam	do	10,112
loam	do	16,640
Total		36,096

Redfield series.

The Redfield series extends from mountain bases across plateau-like plains, upper valley slopes, and sloping plains of narrow valleys to nearly level plains adjacent to the valley trough. The soils of this series are formed of colluvial mountain wash, or sometimes of residual material, mingled with alluvial delta cone deposits of intermittent or torrential streams. They are generally treeless, often gravelly, sometimes marked by rock outcrop, and frequently cut by washes and intermittent stream channels. The soils are derived primarily from red sandstone, modified in places by an admixture of material derived from shales, slates, eruptive rocks, etc., and are typically of vermilion or bright red color. They generally occur as extensive areas. The lower lying and heavier members of the series are often poorly drained and alkaline.

The soils of this series need irrigation to produce any crops. The fine sandy loam type when reclaimed from alkali will produce good crops of alfalfa and grains. Those portions of this type that are above the present system of canals are free from injurious amounts of alkali. The loam of this series is below the canals, and much of it is wet and contains an excess of alkali. In its virgin state it is covered with grease wood. Some portions of this loam are good for general farming. The clay loam of the Redfield series is very stiff and therefore difficult to free from alkali. When partly reclaimed it will produce salt grasses, and it sometimes makes good pasture land. As a whole, the series has not been much developed.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Redfield series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Redfield fine sandy loam	Utah, Wyoming	86,824
loam	Utah	14,100
clay loam	do	3,800
Total		104,724

Salt Lake series.

The Salt Lake series consists of lacustrine sediments and material derived from stream deltas. The soils of this series occur upon low, level plains, marking the site of recent lake bottoms. They are generally barren, deficient in drainage, and heavily impregnated with alkali salts. They are derived from eruptive, sedimentary, and altered rocks of various ages and are without gravel. They cover extensive areas, and are usually dark in color.

The soils of the Salt Lake series are in general not adapted to the production of crops at present, owing to their low-lying position, imperfect drainage, and high content of alkali salts.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Salt Lake series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Salt Lake sand	Utah	2,292
sandy loam	do	51,308
loam	do	19,968
clay loam [a]	do	89,166
Total		162,734

[a] Mapped as Jordan clay in the Salt Lake area, Utah.

Miscellaneous soils of the Great Basin.

The Elsinore sand and Elsinore fine sandy loam are generally leachy and porous or poorly drained and alkaline.

Gypsum, derived from gypsum deposits, is of very little agricultural value.

Meadow, low-lying, flat, and poorly drained land of variable texture. Frequently of some value for grass and pasturage, and in the South for corn after subsidence of floods. Much more of it can be reclaimed by simple methods of drainage, and when this is done excellent results can be secured from a variety of crops.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The Weber fine sandy loam is the most important soil of this group, being devoted to the production of grains, sugar beets, alfalfa, and deciduous fruits when irrigable and free from alkali.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the Great Basin.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Elsinore fine sandy loam	Utah	7,800
Elsinore sand	do	1,900
Gypsum	Wyoming	2,304
Meadow	Utah	25,188
Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash.	do	1,300
Weber fine sandy loam [a]	do	107,904
Total		146,396

[a] Mapped as Fresno fine sandy loam in the Bear River area and Weber County, Utah.

NORTHWESTERN INTERMOUNTAIN REGION.

The most extensive and uniform soil types of this region consist of residual materials overlying and derived from extensive basaltic lava plains and in some cases from granitic rocks or of ancient lacustrine sediments or extensive lake beds now more or less modified by erosion or æolian agencies. Owing to erosion by streams and to movements of the earth's crust, these soils now generally occupy more or less elevated sloping or rolling plains. About the margins of the lacustrine or residual deposits they are covered by sloping plains and fans of colluvial wash from the adjacent mountain borders, while in the vicinity of the larger streams, which have carved and terraced the lacustrine beds and residual soils, occur other series of recent alluvial stream sediments derived from reworked materials of the lake beds or from the weathered products of the mountains. It is the soils of this region that constitute a large portion of the great grain-producing lands of the Northwest.

The aggregate area of the soils surveyed in this province is 1,455,428 acres.

Bridger series.

The soils constituting this series occur upon mountain foot-slopes, lower foothills, high or sloping plains, mesa lands, and alluvial fans or fan deltas, and consist of colluvial mountain waste mixed with stream delta-cone deposits. The higher lying areas are often rough and hilly, marked by rock outcrop, bowlders, or glacial morainic débris, and deeply cut by stream channels. The soils are generally treeless or sparsely timbered, except in the vicinity of streams. The members of this series are derived from granitic rocks, gneiss, basaltic, andesitic, or other volcanic rocks, with an admixture of materials derived from sedimentary rocks, and occupy small irregular to broad extensive areas. The soils are generally of dark color, and are underlain by sticky subsoils of light-gray or yellow color. The soils and subsoils are generally gravelly, the gravel varying from fine angular chips to large, well-rounded or angular blocks and cobbles.

The soils of the Bridger series are usually retentive of moisture and extensively utilized for the production of dry-farmed grains, consisting of wheat, oats, and barley, although irrigation is sometimes necessary for the production of these crops. Under irrigation, alfalfa, clover, timothy, and hardy fruits are also produced to a limited extent.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Bridger series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Bridger gravelly loam[a]	Montana, Oregon	29,760
loam[b]	Oregon	30,784
clay loam	Montana	1,472
Total		62,016

[a] Mapped as Maricopa gravelly loam in the Baker City area, Oregon.
[b] Mapped as Maricopa sandy loam in the Baker City area, Oregon.

Gallatin series.

The Gallatin series occupies lower, nearly level, or slightly sloping stream terraces or alluvial river-valley plains adjacent to stream channels. The soils of this series are formed by recent flood-plain deposits, with an admixture of reworked lake sediments. They are underlain by beds of gravel and cobbles, at depths varying from a few inches to several feet, sometimes partially cemented by lime. The areas are often marked by shallow beds or channels of meandering streams, and are frequently timbered or covered with willow or brush thickets in the vicinity of streams. The members of this series are derived mainly from basaltic, andesitic, or other volcanic rocks, with an admixture of material derived from granites, gneiss, and sedimentary or altered sedimentary rocks. They occur as small irregular to broad extensive areas. The lighter members are of a light-gray color and porous structure, and are usually gravelly, the gravel consisting of well-rounded pebbles. The heavier members are brown to black in color, compact in structure, usually poorly drained, are sticky when wet, and have a tendency to puddle. The areas are often subject to overflow. The soils are underlain by light-gray or yellowish ashy to dark compact subsoils, with frequent occurrences of a compact adobelike structure. They are generally rich in organic matter and of a mucky consistency, except in the lighter, higher lying members.

The soils of the Gallatin series often occupy a low position of deficient drainage and are sometimes injured by the accumulation of alkali salts, but are productive when well drained. They are utilized chiefly for pasture lands and in the production of hay and grain crops. Truck crops and fruits are in favorable locations successfully grown. The Gallatin fine sandy loam, in the Lewiston area, Idaho, occupies a protected position, with climatic conditions favoring intensive fruit culture, and this type here has reached a high state of development in the production of peaches, cherries, plums, prunes, grapes, apples, and other fruits. The gravelly loam is but little developed, and is then used for hay and grain. The loam, silt loam, and clay are often subject to overflow and have not been extensively developed, but are adapted to vegetables, hay, grain, and forage crops.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Gallatin series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Gallatin gravelly loam	Montana, Washington	42,624
fine sandy loam[a]	Idaho, Montana	41,676
loam[b]	Idaho, Oregon, Washington	274,368
silt loam[c]	Idaho, Montana	41,244
clay loam	Montana	896
Total		400,808

[a] Mapped as Yakima fine sand in the Lewiston area, Idaho.
[b] Mapped as Yakima loam in Baker City, Oreg., Blackfoot, Idaho, and Walla Walla, Wash., areas.
[c] Mapped as Yakima silt loam in the Lewiston area, Idaho.

Yakima series.

The members of this series consist of ancient lake sediments, with an admixture of volcanic dust or of residual soils of fine texture, or a mixture of both. The materials have been derived mainly from basaltic and andesitic or granitic rocks. The soils occur upon mountain foot slopes, elevated lava plateaus, tablelands, ridges, or rolling hills, with intervening depressions, sloping valley plains, and elevated stream terraces. The higher areas are often rough and broken and are marked by rock outcrop and forest growth. The lower lying areas are generally gently sloping or undulating, dissected by minor stream channels, and marked by bluff and terrace lines usually strewn with waterworn gravel. The soils of this series generally occur in extensive areas. Both soils and subsoils are of a light-gray to light-brown or buff color, usually porous structure, and ashy texture from a few to many feet in depth. A thin layer of compact adobelike structure sometimes occurs in the subsoils, which are underlain by parent rock or by gravel beds occurring at considerable depths. The soils usually erode rapidly under the influence of streams or irrigation. The subsoils are frequently marked by the presence of pockets of volcanic ash, and are in general open and friable in structure.

The soils of the Yakima series take high rank in the production of grains and of intensively irrigated fruits and other special crops. The stony loam and the sand usually lie above irrigation, are of porous structure, and frequently of wind-blown drifting character, and are relatively unimportant members of the series. The sandy loam is found in Idaho, where it is extensively developed. It is level and fitted for irrigation, but is yet but little used. The fine sand occurs in elevated areas, sometimes wind blown, but when capable of irrigation and cultivation is adapted to tree fruits, vegetables, small fruits, alfalfa, and clover. The fine sandy loam is the most highly developed and intensively cultivated member of the series, and is extensively devoted to the production of choice fruits, consisting of winter apples, peaches, cherries, etc., as well as truck crops, cereals, alfalfa, clover, timothy, and hops. The loam usually occupies elevated positions, and is frequently timbered when occurring in the vicinity of Lewiston and Moscow, Idaho, but these timbered tracts are now being cleared and devoted to wheat, oats, and flax, while the production of winter apples is successfully being carried on to a limited extent. In the Baker City area, Oregon, this type is devoted mainly to the production of oats, barley, and hay crops, but under irrigation is capable of successful culture to fruits and truck crops. The silt loam in the Gallatin Valley, Montana, is devoted to dry-farmed or irrigated grains, and when under irrigation also to the production of alfalfa and clover. In the Lewiston area, Idaho, and Walla Walla area, Washington, it covers large areas of the rolling upland, being devoted principally to the production of wheat and to a limited extent to vegetables, apples, cherries, and small fruits.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Yakima series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Yakima stony loam	Washington	8,960
sand	Idaho	48,448
fine sand [a]	Idaho, Washington	38,090
sandy loam	Idaho	29,760
fine sandy loam [b]	Idaho, Washington	181,452
loam [c]	Idaho, Oregon	29,760
silt loam [d]	Idaho, Montana, Washington	291,712
Total		628,182

[a] The soil mapped as Yakima fine sand in the Lewiston area, Idaho, is the Gallatin fine sandy loam.

[b] The soil mapped as Yakima fine sandy loam in the Walla Walla area, Washington, is Columbia silt loam, and so mapped in Lewiston area, Idaho, is Yakima silt loam.

[c] The soil mapped as Yakima loam in the Baker City area, Oregon, Blackfoot area, Idaho, and Walla Walla area, Washington, is Gallatin loam.

[d] The soil mapped as Yakima silt loam in the Lewiston area, Idaho, is Gallatin silt loam.

Miscellaneous soils of the northwestern intermountain region.

The miscellaneous soils of the northwestern intermountain region consist of a number of types covering extensive areas. They occupy rolling uplands or elevated sloping plateaus and valley plains, and are usually devoted to grains under irrigation or, where climatic conditions permit, to the same crops under systems of dry-farming. Fruits and alfalfa are grown in limited quantities upon some of these soil types under favorable conditions.

The Boise loam and silt loam are underlain by more or less indurated lime hardpan on mesa lands. When this hardpan is not hard nor too near the surface the soils are adapted to grain, fruit, and alfalfa.

The Bozeman silt loam, on account of its topography, has not been developed to any great extent.

The Columbia silt loam is generally devoted to grain.

The Deer Flat fine sandy loam is very little improved for lack of available water for irrigation. When irrigated it is adapted to truck, grain, clover, and fruit.

Meadow is low-lying, flat, and poorly drained land of variable texture, frequently of some value for grass and pasturage. Much more of it can be reclaimed by simple methods of drainage, and when this is done excellent results can be secured from a variety of crops.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The Walla Walla silt loam is well adapted to wheat and barley, giving very large yields of both.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the northwestern intermountain region.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Boise loam	Idaho	61,960
Boise silt loam	do	95,850
Bozeman silt loam	Montana	76,608
Columbia silt loam [a]	Washington	26,688
Deer Flat fine sandy loam	Idaho	45,380
Meadow [b]	Idaho, Oregon, Washington	29,012
Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash.	do	5,564
Walla Walla silt loam	Washington	23,360
Total		364,422

[a] Mapped as Yakima fine sandy loam in the Walla Walla area, Washington.
[b] Mapped as Muck in the Baker City area, Oregon.

ROCKY MOUNTAIN VALLEYS, PLATEAUS, AND PLAINS.

The soils of the Rocky Mountain valleys, plateaus, and plains are derived from a wide range of igneous, eruptive, metamorphic, and sedimentary rocks. The plateau and plain types occupy a more or less elevated position and have sloping, undulating, or irregular surface features. They are derived from underlying sedimentary rocks or consist of the remnants of ancient extensive mountain foot-slope material or of alluvial deposits along streams trenching and terracing the sedimentary rocks of the plateaus and plains. The mountain slope and intermountain valley types consist of residual and colluvial deposits or of ancient lacustrine or later stream sediments, occupying mountain foot slopes and narrow valleys.

The soils of the mountain slopes are usually of little agricultural value, owing to their rough surface, elevated position, and the consequent impracticability of irrigation. Those of the plateaus, valleys, and plains vary widely in economic importance, depending largely upon climatic features, topographic position, and water supply for irrigation. They range from grazing lands of nominal value to soils adapted to the most important and intensively cultivated fruit, melon, sugar beet, and other special crops.

The aggregate area of the soils surveyed in this province is 2,939,840 acres.

Billings series.

The soils of the Billings series consist of ancient stream-deposited material, with an admixture of residual and colluvial material derived from shales, sandstones, or adjacent soil bodies. They occur in old elevated stream terraces, stream flood plains, and in sloping valley plains or as second bottoms of stream valleys carved from the sedimentary rocks of elevated plains and plateaus. The surface is frequently cut by arroyos, or intermittent stream channels. The soils often cover extensive areas and are prevailingly of dark or nearly black color, and frequently of compact, sticky, adobelike structure. In depressions or along lower slopes subject to seepage from irrigation from more elevated soil bodies they are frequently poorly drained and filled with alkali. When properly drained and cultivated they are valuable and productive soils.

The soils of the Billings series are utilized mainly in the production of grains, sugar beets, and hay crops. The gravelly loam and the fine sandy loam are well-drained types free from alkali and valued for their adaptation to the production of alfalfa, sugar beets, fruits, and vegetables. In the Grand Junction area, Colorado, the peach and apple industries have reached a high state of development on the latter type. The loam, silt loam, clay loam, and clay are of less importance in fruit-producing industries, but are generally utilized for the production of sugar beets, hay crops, grains, and sometimes vegetables.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Billings series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Billings gravelly loam	Montana	11,776
fine sandy loam	Colorado, Montana	40,512
loam	Colorado	41,984
silt loam	do	9,664
clay loam[a]	Colorado, Montana	30,272
clay	Colorado, Montana, Wyoming	38,912
Total		173,120

[a] Mapped as Billings loam in the Billings area, Montana.

Colorado series.

The soils of the Colorado series consist of colluvial and alluvial material of ancient mountain foot slopes, more or less modified by or mingled with recent alluvial wash and with residual material derived from underlying sandstones, limestones, or shales. They occupy elevated undulating prairies or treeless plains, marked by occasional low, rounded ridges or hills, deep, narrow arroyos, or broad, gently sloping valleys. In eroded districts bluff or terrace lines, strewn with waterworn pebbles and outcropping ledges of sedimentary rocks, are frequent. The smaller stream valleys are often subject to overflow, and the uplands are frequently marked by depressions or local drainage basins. The transported material is derived largely from granitic and allied rocks of the Rocky Mountains. The soils and subsoils are generally of light-gray to reddish-brown or light-brown color, and frequently occur as extensive areas. They are generally productive under irrigation, but sometimes poorly drained and alkaline in depressions when subject to seepage from higher elevations.

The soils of this series usually occur in extensive bodies and frequently occupy positions above present irrigation facilities, or are sometimes rendered unproductive locally through the accumulation of seepage waters and alkali. The gravelly loam, sand, and sandy loam are well-drained types free from alkali, but frequently unirrigable owing to their position above present irrigation systems. Where irrigated, alfalfa, sugar beets, melons, vegetables, and some small fruits are profitably grown. The fine sandy loam and the loam are sometimes poorly drained, but are in general valuable soil types utilized extensively for the production of alfalfa, sugar beets, potatoes, and grains when brought under irrigation. The clay loam and the loam adobe are devoted chiefly to alfalfa and to grain crops.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Colorado series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Colorado gravelly loam	Colorado	33,408
sand [a]	Colorado, Kansas	139,520
sandy loam [b]	do	183,296
fine sandy loam	Colorado	196,480
loam	Colorado, Kansas	125,824
clay loam [c]	Colorado	832
loam adobe	do	42,880
Total		722,240

[a] Mapped as Fresno sand and Maricopa sand in the Lower Arkansas Valley area, Colorado.
[b] Mapped as Maricopa sandy loam in the Lower Arkansas Valley area, Colorado.
[c] Mapped as Maricopa clay loam in the Lower Arkansas Valley area, Colorado.

Finney series.

The Finney fine sandy loam is a very productive type, being adapted to the common grain crops, such as corn, wheat, and oats, as well as to alfalfa, from which four cuttings are obtained. Brome grass and fescue yield heavily. Corn yields from 25 to 60 bushels per acre, wheat from 20 to 25 bushels, oats from 35 to 45 bushels, and sugar beets 5 tons per acre. Much of this soil is still in pasture. Modern machinery is seen in the alfalfa fields, and the most improved farms are on this type. Generally the fine sandy loam is not strongly alkaline. The loam of this series is sufficiently rolling to admit of excellent drainage, and practically all of this soil is suitable for cultivation. It supports in some places a good growth of prairie grass. It is very productive and adapted to a diversity of crops, their growth being controlled more by the moisture supply than by the fertility of the soil. Corn, wheat, and oats are grown, while alfalfa, clover, brome grass, and fescue also do well. Corn yields from 25 to 40 bushels, wheat from 15 to 35 bushels, and alfalfa from 2 to 3 tons to the acre. Only a small area is devoted to oats. About one-half of the area surveyed is in pasture. The farmers must depend upon rainfall for water supply, since there is no water available for irrigation. The areas of Finney clay are small in extent. None of it is under cultivation, but nearly all the meadows are covered by native grasses which constitute excellent hay crops. From 1½ to 2½ tons of hay per acre are secured. Wheat and flax might be grown on the better drained meadows, where there is no danger of standing water. This type is at present of no agricultural value. The greater portion of the sandy loam of this series on the uplands is used for range purposes, though an occasional field of sorghum is found. On the second bottom lands where this soil is found alfalfa is often planted, which is more remunerative as a seed crop than as forage. The soil is free from alkali, but the subsoil contains considerable lime.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Finney series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Finney sandy loam	Kansas	6,272
fine sandy loam	Nebraska	40,128
loam	Nebraska	11,008
clay	North Dakota	3,264
Total		60,672

Fruita series.

The soils of the Fruita series are similar in origin, mode of formation, and topographic features to those of the Billings and the Mesa series. They are usually of a reddish-brown color, somewhat compact structure, though friable under cultivation, and in lower depressions are often poorly drained and filled with alkali.

The soils of this series are of a very productive character, but have been considerably injured by poor drainage and the collection of seepage waters and alkali. They are well adapted to the production of fruits and sugar beets. Apples and pears are profitably grown upon the better drained portions of areas covered by both types, but they are for the most part at present generally utilized for the production of alfalfa, grains, sugar beets, and vegetables.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Fruita series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Fruita fine sandy loam	Colorado	3,968
loam	do	512
Total		4,480

Laramie series.

The Laramie series occurs upon mountain foot slopes and high, broken, sloping or undulating plains. The surface is often gravelly or strewn with cobbles or bowlders, and is frequently cut by intermittent stream channels or marked by rock outcrop. Depressions or basins of intermittent lakes frequently occur. The soils consist of colluvial mountain waste modified by alluvial stream wash or glacial débris, and are derived from granitic rocks, gneiss, schist, quartzites, etc., with an admixture of material from sedimentary rocks. They occur as extensive areas of dark-colored soils, generally underlain by light-colored gravelly subsoils, and are well drained and free from alkali, except for local poorly drained depressions.

The gravelly loam is a well-drained type, free from alkali, but owing to its open, porous structure and topographic position is generally at present of but little agricultural value, save for grazing purposes. The sandy loam is well adapted to general farm crops, and is devoted principally to the production of wheat, oats, potatoes, and alfalfa.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Laramie series.

Soil name.	States in which each type has been found.	Total area
		Acres.
Laramie gravelly loam	Wyoming	19,200
sandy loam	do	86,272
Total		105,472

Laurel series.

The soils of the Laurel series occupy low, nearly level or slightly sloping stream terraces and river flood plains or more elevated slopes adjacent to intermittent streams subject to flood. They consist of recent alluvial sediments deposited from the turbid flood waters of wide, shallow, shifting streams traversing elevated valleys, plains, or plateaus. The soils vary in color from light gray to reddish brown or black, according to position and the quantity of organic matter present, and are often poorly drained and filled with alkali.

The fine sand and the fine sandy loam are of loose, leachy character and subject to overflow. They are usually devoted to pasture or to sugar beets, truck crops, and, when the water table does not too closely approach the surface, to alfalfa. The fine sandy loam occurring in the Russell area, Kansas, and Sarpy County, Nebr., is utilized chiefly in the growing of corn and alfalfa. The loam and loam adobe are devoted mainly to the production of alfalfa, sugar beets, and grains. The clay loam, which occurs in the San Luis Valley, Colorado, is not, however, esteemed desirable for grain or alfalfa, but is utilized mainly for pasture.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Laurel series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Laurel gravelly loam	Nebraska	16,448
fine sand[a]	Colorado, Kansas, Nebraska	16,512
sandy loam	Colorado, Kansas, Montana, Nebraska, Wyoming	136,960
fine sandy loam	Kansas, Nebraska, North Dakota	21,632
loam	Colorado, Kansas, Nebraska, North Dakota	118,016
silt loam	North Dakota	18,880
clay loam	Colorado, Kansas, North Dakota	27,008
loam adobe	Kansas	1,472
clay	North Dakota	6,656
Total		363,584

[a] Mapped as Fresno fine sand in the Lower Arkansas Valley, Colorado.

Mesa series.

In origin, mode of formation, and topographic features the soils of the Mesa series are similar to those of the Billings and the Fruita series. They consist of former flood-plain deposits now existing as old elevated river terraces or mesa lands. The surface is often rough and hilly. The soils generally vary from light gray to chocolate brown in color, are friable to compact in structure, and are underlain by shale and sandstone rock. They are sometimes poorly drained and impregnated with alkali in small local depressions.

The fine sandy loam occurs mainly in uncultivated tracts, which are gradually coming into use for the production of orchard fruits, alfalfa, and truck crops, for which this soil is admirably adapted. The clay loam and clay are sometimes poorly drained, and these types are chiefly utilized in the cultivation of sugar beets, alfalfa, and grain.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Mesa series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Mesa fine sandy loam	Colorado	34,432
clay loam	do	2,240
clay	do	22,464
Total		59,136

Morton series.

The Morton series includes soils derived principally from the sandstones and shales of the Laramie formation. They are brown in color, owing to the accumulation of a considerable amount of organic matter. Being formed in a region of low rainfall, these soils and especially the subsoils are usually rich in lime.

The most important soil in the Morton series is the loam which comprises the greater part of the safe farming land in the upland portion of Morton County, N. Dak. It is very productive, retentive of moisture, and easily tilled. In average seasons it produces good crops of wheat, flax, and oats. The fine sandy loam, while not so retentive of moisture as the loam, is usually a good farming soil and for many years it has produced a good average of profitable crops. The texture adapts it to truck crops and vegetables that require a rapid growth during a short season. For this reason it is better adapted to corn than are some of the other soils, but the possibility of injury from drought is greater than in the heavier soils. The stony loam furnishes excellent grazing. The open, porous nature and topography of the fine sand render it unable to retain moisture, so that the areas have a very low agricultural value except for grazing. In McKenzie County, N. Dak., where the silt loam has been mapped none of the type has ever been broken up for cultivation and probably not more than 2 per cent is mowed for hay. It is used almost entirely for grazing. It is one of the best upland soils of this section and if climatic conditions were favorable it would produce fine crops. The clay loam, clay, and gumbo are used for pasture.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Morton series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Morton stony loam	North Dakota	48,128
fine sand	do	4,352
fine sandy loam	do	117,952
loam	do	163,456
silt loam	do	104,576
clay loam	do	17,024
clay	do	704
gumbo	do	8,448
Total		464,640

San Luis series.

The material forming the San Luis series was derived originally from volcanic rocks, principally trachyte, and represents ancient lacustrine sediments or lake beds, more or less modified by subsequent alluvial wash, wind drifting, and weathering. The soils occupy filled valleys as broad, nearly level, or gently sloping plains, the surface being broken only by small mounds or ridges or by forms produced by wind-drifting. They occur as small irregular to broad, extensive areas, often gravelly, the gravel consisting of medium to fine fragments. The soils are of reddish-brown color, porous structure, and are underlain by sands and coarse, rounded gravel. The lower lying bodies are often subject to injury from seepage and accumulation of alkali from irrigation upon higher adjacent soils.

The sand is a loose, porous soil requiring heavy irrigation, which has been followed in the San Luis Valley, Colorado, where these soil types occur, by more or less injury from the collection of seepage waters and alkali. The same is true more or less of the sandy loam. Both these soils are devoted mainly to the production of grains and field peas. The loam is a poorly drained type containing more or less alkali and is of minor agricultural importance.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the San Luis series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
San Louis sand	Colorado	136,960
sandy loam	do	196,992
loam	do	9,088
Total		343,040

Wade series.

The Wade series consists of brown to dark-brown alluvial soils formed by the reworking of the sandstones and shales belonging principally to the Laramie formation. They occur throughout the area where the Morton soils form the uplands. They contain a considerable amount of lime, and some of the more poorly drained areas contain alkali.

The soils of the Wade series are good farming soils when rainfall is sufficient. The fine sandy loam is now largely under cultivation in Morton County, N. Dak., and oats, flax, millet, and corn, and, to a less extent, wheat, are grown with profitable results. Heretofore oats have been the most successful and profitable crop. All kinds of vegetables may be produced in large quantities when there shall arise a demand for such products, but at present they are grown only for home use. The silt loam has a large amount of humus that gives it a dark color and a loamy character, which makes it easily tilled. A considerable proportion is cultivated, as it is a favorite type of soil with the homesteader. It is very productive, withstands drought well, and is well adapted to any of the usual field crops. The loam is the most desirable of the series, agriculturally. The soil is retentive of moisture and advantageously situated for purposes of general farming, and especially for stock raising. None of the clay has yet been cultivated, although it is a productive soil, and aside from the difficulties of tillage it should be very desirable farming land. The small areas make excellent hay meadows.

The acreage of the types so far encounted is as follows:

Area and distribution of the soils of the Wade series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Wade fine sandy loam	North Dakota	12,608
loam	do	8,576
silt loam	do	28,352
clay	do	8,256
Total		57,792

Miscellaneous soils of the Rocky Mountain valleys and plains.

The Fort Collins loam is generally level, with occasional slight undulations. It is for the most part a residual soil formed by the weathering in place of shaly sandstones and sandy shales. The type is well adapted to wheat, oats, barley, alfalfa, sugar beets, potatoes, and apples.

Very little of the Gannett fine sand is cultivated, most of it being utilized as pasture. It occurs in the bottoms along the foot of the sandhills in Nebraska.

The Lancaster fine sandy loam is very limited in extent and is not a good soil for general farming.

The North Platte loam occupies level second bottoms along the Platte River. Corn and alfalfa produce well, and wheat, sugar beets, fruits, and vegetables should be fairly successful.

The Orman clay consists of material washed from the Pierre shale and deposited in lakes. At the present time hardly any of this land is under cultivation, but it is probably well adapted to crops grown in this section. The soil contains considerable alkali, and proper methods to guard against injury from this source should be adopted when it is put under irrigation.

The Osgood fine sandy loam represents colluvial wash from the more sandy loess in central Nebraska. It is a fine soil, producing good crops of corn, wheat, oats, alfalfa, sugar beets, and hay.

The Pierre clay is quite extensively developed, being derived from the Pierre shale. The acreage farmed is very small, and the type is used largely for grazing purposes. It gives a fair growth of native grasses, and the lower lying portions are sometimes cut for hay. Small irrigated areas give good crops.

The Pierre clay loam supports a good growth of grass and is used to a limited extent as a range for stock. Near the streams the growth of grass is heaviest, and here it is cut for hay. Some of the type is farmed without irrigation, the principal crops being alfalfa and oats, with some wheat and corn. The yields vary widely, being dependent upon the rainfall.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The Scoria gravel and Epping clay are of little agricultural importance.

Sandhill and Dunesand are deep sands of little agricultural value.

Swamp and Marsh comprise areas covered with water the greater part of the year and unfit for agriculture, except where drained and protected from tidal or fluvial overflow. When reclaimed much of this land will become very productive.

Both dry farming and farming under irrigation are practicable on the Vale fine sandy loam. In the dry-farming section it produces good crops of alfalfa, oats, and corn in seasons of average rainfall. Under irrigation alfalfa produces 5 to 7 tons, oats 60 to 70 bushels, and wheat 25 to 35 bushels per acre. Corn also gives good returns when not damaged by early frosts.

On account of its steep surface slope a large part of the Vale gravelly sandy loam is suited only to pasture. Under irrigation the more level areas should prove well adapted to such fruits as thrive on gravelly soils in this climate.

Alfalfa and small grains, principally oats and wheat, do well on the Vale loam, and the yields approximate those obtained on the fine sandy loam. In the Red Water and Spearfish valleys, South Dakota, this soil has proved well adapted to apples, plums, cherries, and small fruits.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the Rocky Mountain valleys and plains.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Epping clay	North Dakota	384
Fort Collins loam	Colorado	14,144
Gannett fine sand	Nebraska	8,448
Lancaster fine sandy loam	do	2,368
Meadow	do	46,272
North Platte loam	do	23,936
Orman clay	South Dakota	14,912
Osgood fine sandy loam	Nebraska	16,320
Pierre clay	South Dakota	41,088
Pierre clay loam	do	24,192
Rock outcrop, etc	Colorado, Kansas, Nebraska, North Dakota, Wyoming.	86,080
Sandhill and Dunesand	Colorado, Kansas, Nebraska	248,192
Scoria gravel	North Dakota	25,920
Swamp and Marsh	Colorado, Montana	3,648
Vale fine sandy loam	South Dakota	23,936
Vale gravelly sandy loam	do	2,304
Vale loam	do	3,520
Total		585,664

ARID SOUTHWEST.

The soils of the arid Southwest are mainly of colluvial, alluvial, and lacustrine origin. They occupy mountain foot slopes, alluvial fans, débris aprons, or sloping plains of filled valleys, sloping or nearly level plains, and bottoms of stream valleys or sinks and drainage basins. The principal colluvial soils of this region are also common to the Pacific coast. The climate of the arid Southwest is characterized by semitropical desert conditions, and where the soils are not capable of irrigation they have little or no present agricultural value. The aggregate area of the soils surveyed in this province is 1,131,155 acres.

Gila series.

The Gila series consists of recent stream deposits derived from a variety of rocks, and occurs over river flood plains and lower stream-formed terraces. The soils of this series are generally subject to overflow, and are often eroded or modified by torrential floods, cut by stream channels, more or less wind drifted, and frequently covered with dense thickets of willow, cottonwood, mesquite, canaigre, or other small timber or bushes. They are of light to dark brown color. The soils of this series are sometimes interstratified with minor layers of heavier sediments and are distinguished from those of the Imperial series by being underlain at varying depths by coarse river sands and gravels. The fine sandy loam and the fine sand, when irrigable and well drained, are well adapted to the production of fruit, truck crops, melons, potatoes, and alfalfa, but the surface is sometimes uneven and the soils are occasionally poorly drained or affected with alkali.

The other soils of this series are frequently subject to overflow or are poorly drained and contain alkali, but when well drained they are adapted to alfalfa, grains, or other general farm crops.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Gila series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Gila fine sand [a]	Arizona, California, New Mexico	31,042
fine sandy loam [b]	Arizona	43,794
loam [c]	Arizona, California	79,232
silt loam	.....do	12,672
clay loam	.....do	24,384
clay	.....do	17,751
Total		208,875

[a] Mapped as Imperial sand in the Yuma area, Arizona-California.
[b] Mapped as Gila fine sandy loam in the Solomonsville area, Arizona, and the Imperial area, California.
[c] Mapped as Imperial sandy loam in the Yuma area, Arizona-California.

Imperial series.

The Imperial series consists of old marine or lacustrine sediments more or less covered or modified by subsequent river overflow deposits. The soil types of this series are derived from a variety of rocks and usually occur as extensive bodies covering low, level, or slightly sloping valley floors. Unlike the soils of the Gila series, they are underlain to great depths by heavy sediments of close and more or less impervious nature. The surface is sometimes marked by bluff or shore lines, sloughs, or stream channels, and is usually considerably modified by drifting. The soils are generally of light or reddish color, and in the heavier members are frequently poorly drained and filled with alkali. The sand and sandy loam are important types of this series adapted to the production of fruits, truck crops, and alfalfa or forage crops under irrigation. The clay loam and the clay frequently contain an excess of alkali salts and are cultivated with difficulty, owing to heavy or fine texture and compact structure, but if well drained are suitable for the production of alfalfa, sorghum, and millet.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Imperial series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Imperial sand [a]	California	1,792
sandy loam [b]	.....do	126,656
clay loam	.....do	341,056
clay	.....do	46,912
Total		516,416

[a] The soil mapped as Imperial sand in the Yuma area, Arizona, is the Gila fine sand.
[b] The soil mapped as Imperial sandy loam in the Yuma area, Arizona-California, is the Gila fine sandy loam.

Indio series.

The Indio series occurs in desert valleys, covering sloping valley plains, upper valley slopes at the foot of mountain ranges, and mountain foot slopes. The soils are derived mainly from granitic rocks, mingled with some shale and sandstone material, and are formed by colluvial and alluvial wash from intermittent or torrential streams, and in certain cases have been deposited in the waters and modified by the shore deposits of ancient lakes or bays. They are generally of light color and porous structure, usually underlain by coarser sands and gravels, and their surface is rough and hilly, scarred by the channels of intermittent streams or drifted by winds. The fine sand is an important agricultural type of this series, adapted particularly to the production of sweet potatoes, melons, and vegetables. It is of special importance in the cantaloupe industry of the arid Southwest. It is also a good soil for forage crops. The fine sandy loam is adapted to the same crops, though often poorly drained and affected with alkali. In most cases the gravelly loam and the sand either lie above the irrigation systems or have a surface too uneven for irrigation; but when irrigable and free from alkali they are usually adapted to the production of fruits and vegetables.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Indio series.

Soil name.	State in which each type has been found.	Total area.
		Acres.
Indio gravelly loam	California	43,328
sand [a]	do	50,112
fine sand [b]	do	36,032
fine sandy loam [c]	do	42,432
Total		171,904

[a] Mapped as Fresno sand in the Indio area, California.
[b] Mapped as Fresno fine sandy loam in the Indio area, California.
[c] Mapped as Fresno sandy loam in the Indio area, California.

Miscellaneous soils of the arid Southwest.

The Pecos sandy loam is a well-drained soil, free from alkali and is usually recognized as the best general farming land of the localities in which it occurs.

The Roswell fine sandy loam and the Roswell loam are rather poorly drained and frequently contain injurious amounts of alkali, but when well drained and free from alkali are well adapted to the production of alfalfa and general farm crops.

The Yuma sand has a level, smooth surface, is well drained, and is adapted to the production of citrus fruits, figs, grapes, vegetables, melons, etc.

The Glendale clay loam is usually well drained, free from alkali, and adapted to grain, alfalfa, and in the case of the lighter phases to fruits.

The Pecos conglomerate is a nonagricultural type.

Gypsum is found on level bench lands in New Mexico. It is derived from gypsum deposits and is of little agricultural value.

Meadow consists of low-lying, flat, and poorly drained land of variable texture. It is frequently of some value for grass and pasturage. Much more of it can be reclaimed by simple methods of drainage, and when this is done excellent results can be secured from a variety of crops.

Rock outcrop, Rough stony land, Steep broken land, Rough broken land, and Riverwash are mainly nonagricultural land.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the arid southwest province.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Glendale clay loam	Arizona	52,040
Gypsum	New Mexico, Wyoming	11,630
Meadow	New Mexico	7,940
Pecos conglomerate	do	11,680
Pecos sandy loam	do	36,310
Roswell fine sandy loam	do	9,090
Roswell loam	do	2,730
Yuma sand	Arizona	94,400
Rock outcrop, etc	do	8,140
Total		233,960

PACIFIC COAST.

The soils of the Pacific coast, including those of the coastal and interior mountain ranges, foothills, and valleys, have been classified into a number of series, varying in field characteristics, topography, origin and mode of formation, and agricultural importance. They range from residual and colluvial soils of the mountain sides, foot slopes, and foothills, to deep and extensive river flood plains and delta sediments, and ancient and modern shore and marine lacustrine deposits. While some of these series are confined to a single coastal or interior mountain range or valley, others are of wider range and extend over several different physiographic regions. The value of these soils and their adaptation to crops is dependent largely upon the possibilities of irrigation and upon local conditions of rainfall and temperature, all of which are to a great extent dependent upon topography. They range in agricultural importance from those devoted only to extensive grain farming to the most valuable and intensively cultivated lands devoted to citrus and deciduous fruits, vines, small fruits, and other special crops. The aggregate area of the soils surveyed in this province is 4,593,881 acres.

Anderson series.

The soils of the Anderson series consist of reddish-gray or light-red alluvial soils occupying upper valley plains and the bottoms of intermittent streams. They are usually gravelly, sometimes underlain at less than 6 feet by stream gravels or by compact clays and clay loams, and often support a considerable growth of brush and timber. When not too gravelly they are adapted to the production of peaches, pears, prunes, and small fruits, but are, so far as mapped at present, inextensive types and of secondary agricultural importance, the Anderson gravelly loam being the prevailing and most important soil of the series.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Anderson series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Anderson gravelly loam	California	14,528
fine sandy loam	do	3,520
Total		18,048

Fresno series.

The soils of the Fresno series are characterized by prevailing light-gray colors, but are sometimes light brown or reddish brown. They are generally underlain by subsoils of fine ashy texture, light color, and compact, close structure, usually separated from the overlying soil by an alkali carbonate hardpan of white or light-gray color. The hardpan softens slowly upon the application of irrigation water, but is normally impenetrable to the roots of growing plants. The series is composed of old delta deposits formed by shifting streams and mountain torrents and occurring as broad, low alluvial delta cones. The soils occupy gently sloping plains or slightly rolling valley slopes, generally treeless, and are not usually overflowed. The soil material of this series is mainly of granitic origin, although in part derived from volcanic and sedimentary rocks. The lighter members, since they occupy higher positions, are generally well drained. The lower lying areas frequently require drainage, being subject to seepage from higher lying tracts and also contain some alkali. The sand and fine sand, with intensive methods of cultivation and irrigation, are used for the production of peaches, apricots, cherries, prunes, figs, walnuts, and raisin and wine grapes. They are also well adapted to alfalfa and to vegetables under irrigation. The sandy loam and fine sandy loam are productive soils and excellently adapted to fruits and alfalfa, though large areas have been damaged by seepage and the accumulation of alkali.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Fresno series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Fresno sand [a]	California	193,526
fine sand [b]	do	8,128
sandy loam [c]	do	5,952
fine sandy loam [d]	do	90,975
loam [e]	do	5,824
Total		304,405

[a] The soil mapped as the Fresno sand in the Lower Arkansas Valley area, Colorado, is the Colorado sand; that mapped as Fresno sand in the Indio area, California, is Indio sand; that mapped as the Fresno sand (gravelly phase) in the Ventura area, California, is Maricopa sand; that mapped as Fresno sand in Bakersfield, Los Angeles, Lower Salinas Valley, Sacramento, San Bernardino, San Gabriel, and Santa Ana areas, California, is Hanford sand; and that mapped as the Fresno sand in Provo area and in Weber County, Utah, is Jordan sand.

[b] The soil mapped as the Fresno fine sand in Lower Arkansas Valley, Colorado, is Laurel fine sand; that mapped as Fresno fine sand in Bakersfield and Los Angeles areas, California, is Hanford fine sand; and that mapped as Fresno fine sand in Sacramento area, California, is Hanford fine sandy loam.

[c] The soil mapped as Fresno sandy loam in Fresno and Hanford areas, California, is the Fresno fine sandy loam, and that mapped as Fresno sandy loam in the Indio area, California, is the Indio fine sand.

[d] The soil mapped as Fresno fine sandy loam in the Lower Arkansas Valley area, Colorado, is the Marshall silt loam; that mapped as Fresno fine sandy loam in Weber County and in Bear River area, Utah, is Weber fine sandy loam; that mapped as Fresno fine sandy loam in Indio area, California, is Indio fine sandy loam; that mapped as Fresno fine sandy loam in the Ventura area, California, is the Oxnard loam; that mapped as Fresno fine sandy loam in the Bakersfield, Lower Salinas Valley, Los Angeles, San Bernardino, San Gabriel, and Santa Ana areas, California, is the Hanford fine sandy loam; and that mapped as Fresno fine sandy loam in San Jose area, California, is the Hanford silt loam.

[e] Mapped as Maricopa loam in Bakersfield area, California.

Hanford series.

The soils of the Hanford series consist of recent alluvial materials derived from a great variety of rocks and deposited as river and delta plains. The lighter members sometimes consist largely of mining débris and overlie Pleistocene sediments and hardpan. They are generally light gray to buff in color, but become dark drab, brown, or nearly black in the case of some of the heavier members occupying low-lying positions. All the members of the series are subject to much variation in depth, color, and character of underlying material. The surface is generally level, slightly sloping, or sometimes uneven, and is frequently marked by sloughs or the interlacing channels of streams, many of which carry water only in times of flood and disappear in sandy washes. The heavier members are frequently marked by an adobe structure, and the soils are generally free from gravel or bowlders. The lighter members and higher lying soil bodies are usually well drained and are not affected by seepage caused by irrigation, while the natural drainage is sometimes deficient in the case of lower lying areas occupying present stream flood or overflow delta plains, where protection by levees becomes necessary. While similar to the soils of the Fresno series in mode of formation, they generally occupy a lower topographic position, are of more recent origin, are frequently subject to overflow, and, unlike the former, often support a growth of swamp vegetation, brush and willow thickets, and timber in the river bottoms and lower valley plains. The heavier members are also usually of darker color, while the underlying white hardpan and subsoils of ashy texture common in the Fresno series are wanting here. The soils are usually productive and are especially adapted to fruits, vines, vegetables, and truck crops when well drained, free from alkali, and irrigated. The lighter soils of the Hanford series, consisting of the sand, fine sand, sandy loam, and fine sandy loam, are productive and easily cultivated, and utilized in the production of alfalfa, pears, stone fruits, grapes, English walnuts, small fruits, asparagus, celery, and other truck crops. The sand is, however, while a fair fruit and truck soil when well irrigated, of a somewhat leachy character and deficient in organic matter. The soils of this series are also often subject to overflow, and, with the exception of the sand in some places, poorly drained and affected with alkali. The silt loam is also devoted to the production of potatoes, beans, sugar beets, and hops, in addition to the crops enumerated above.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Hanford series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Hanford gravel	California	4,544
sand [a]	do	224,680
fine sand [b]	do	118,338
sandy loam	do	19,860
fine sandy loam [c]	do	151,194
silt loam [d]	do	73,137
clay loam [e]	do	17,896
clay adobe [f]	do	12,672
Total		622,321

[a] Mapped as the Fresno sand in the Bakersfield, Los Angeles, Lower Salinas, Sacramento, San Bernardino, San Gabriel, and Santa Ana areas, California.
[b] Mapped as Fresno fine sand in the Bakersfield and Los Angeles areas, California.
[c] Mapped as the Fresno fine sand in the Sacramento area, California, and as the Fresno fine sandy loam in Bakersfield, Lower Salinas, Los Angeles, San Bernardino, San Gabriel, and Santa Ana areas, California.
[d] Mapped as the Fresno fine sandy loam in San Jose area, California, and as the Sacramento silt loam in the Sacramento area, California.
[e] Mapped as the Oxnard silt loam in the Bakersfield area, California.
[f] Mapped as the Salinas gray adobe in the Sacramento area, California.

Maricopa series.

The Maricopa series consists of unassorted colluvial and only partially assorted alluvial material formed by soil creep and direct washing from the mountain sides and by the deposits of intermittent, shifting, torrential streams. The soils of this series are derived from a variety of rocks, but generally from those of granitic and volcanic character. They occupy mountain foot-slopes, delta cones or fans, débris aprons, and sloping plains of filled valleys, and also occur in stream valleys as the product of a series of minor secondary fans or cones emerging from adjacent more elevated slopes or mesa lands. They are generally treeless, and support only a desert vegetation, except when irrigated, are frequently cut by arroyos, and the lighter members are usually gravelly and often strewn with bowlders. These soil bodies vary from small areas of irregular outline to broad, extensive, uniform sheets. The soils are generally of dark color and loose, porous structure. They are generally well drained and free from alkali, and where capable of irrigation are well adapted to fruits, vines, and general farm crops. The gravelly loam and the gravelly sand are well drained and free from alkali, but in many cases can not be irrigated, and are then devoted to grazing or dry-farming to grains or to the production of grapes. Extensive areas are, however, irrigated and used for the production of grains, grapes, citrus fruits, and stone fruits. In the San Gabriel area these types are used extensively for grains and for the production of citrus fruits. In the San Jose area large quantities of early peaches, apricots, prunes, other stone fruits, and grapes are produced. The sand is sometimes broken, hilly or wind-blown in character, but when favorably situated for irrigation is adapted to fruits, vines, and general farm crops. In the Ventura area it has been found a valuable soil for lima beans. The sandy loam and the fine sandy loam are usually free from alkali and well drained. Under irrigation they are good soils for alfalfa, grains, citrus fruits, deciduous fruits, small fruits, and truck crops. In the Los Angeles area they are devoted quite extensively to grapes, alfalfa, strawberries, lemons, and winter vegetables. The silt loam and the clay loam are not well drained, and accumulations of alkali occur. The best-drained areas produce alfalfa, wheat, barley, sorghum, and in some localities sugar beets.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Maricopa series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Maricopa gravelly sand	California	194,886
gravelly loam [a]	Arizona, California	98,226
sand [b]	do	28,318
sandy loam [c]	do	47,680
fine sandy loam	do	112,858
loam [d]	Arizona	33,514
silt loam	do	11,648
clay loam [e]	do	8,713
Total		535,843

[a] The soil mapped as Maricopa gravelly loam in the Provo area, Utah, is the Bingham gravelly loam; that mapped as Maricopa gravelly loam in the Baker City area, Oregon, is the Bridger gravelly loam; and that mapped as Maricopa gravelly loam in Los Angeles area, California, is the Maricopa fine sandy loam. Mapped as Maricopa sandy loam in San Bernardino area, California, and that mapped as Maricopa gravelly loam in the Solomonsville area, Arizona, is Maricopa loam.

[b] The soil mapped as Maricopa sand in the Lower Arkansas Valley area, Colorado, is the Colorado sand. Mapped as Fresno sand (gravelly phase) in Ventura area, California.

[c] The soil mapped as Maricopa sandy loam in Baker City area, Oregon, is the Bridger loam; soil mapped as Maricopa sandy loam in Lower Arkansas Valley, Colorado, is Colorado sandy loam; and that mapped as Maricopa sandy loam in Salt River Valley, Arizona, is Maricopa fine sandy loam.

[d] The soil mapped as Maricopa loam in Bakersfield area, California, is Fresno loam.

[e] The soil mapped as Maricopa clay loam in Lower Arkansas Valley area, Colorado, is Colorado clay loam.

Oxnard series.

The soils of the Oxnard series consist of delta-plain deposits, colluvial and alluvial wash from foothills and higher adjacent soil bodies, and occasional small areas of residual material. They are derived mainly from sandstones, shaly sandstones, and shales, and occur upon rolling hills, sloping, elevated, and dissected mesa lands and plains, and lower nearly level valley and delta plains. They usually occupy a less elevated position than the soils of the Maricopa series, are derived from less elevated foothills and ranges, and are lacking in the granitic material of the former series. They are generally of dark color and are most frequently underlain by heavier subsoils, which, however, do not have the red color and adobe structure of the subsoils of the Placentia series, occupying a similar topographic position. The soils of the Oxnard series occur in the vicinity of Oxnard, Cal., and are recognized as particularly adapted to the production of lima beans, which industry has been here highly developed. The gravelly loam, sand, sandy loam, loam, and silt loam are utilized extensively for this purpose. In other parts of southern California these types are also devoted to the production of walnuts, berries, truck crops, and citrus and deciduous fruits. The soils of this series are usually productive, but sometimes local areas are poorly drained or marked by the accumulation of alkali salts. The heavier and slightly alkaline areas are usually best adapted to the production of barley or of sugar beets, which are extensively produced upon the heavier types of this series.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Oxnard series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Oxnard gravelly loam	California	16,270
sand	do	56,520
sandy loam	do	75,600
fine sandy loam	do	22,848
loam [a]	do	19,812
silt loam [b]	do	31,240
clay loam	do	30,574
clay loam adobe	do	134,598
Total		387,462

[a] The soils mapped as Oxnard loam in Los Angeles, San Jose, and Ventura areas, California, are Oxnard clay loam. Mapped as Fresno fine sandy loam in Ventura area, California.

[b] The soil mapped as Oxnard silt loam in Bakersfield area, California, is Hanford clay loam.

Placentia series.

The soils of the Placentia series vary considerably in origin, mode of formation, and topographic position. In general, however, they consist of colluvial waste and of alluvial and colluvial deposits of intermittent or torrential mountain streams, though in some cases they are composed essentially of residual material. In nearly all cases they have been subject to considerable modification subsequent to their formation by weathering and through the addition of alluvial wash from minor streams. They occur upon undulating hills, mountain foot slopes, mesa lands, and broad, uniformly sloping fan deltas and higher valley plains. They are distinguished from the soils of the Maricopa series of somewhat similar topographic position and mode of formation, by the prevailing reddish-gray to reddish-brown color and in being underlain by indurated sands, shaly sandstones, disintegrated granite, or more generally by heavy, compact red loams or clay loams of tough, impervious adobe structure. The soils of this series are derived mainly from granitic rocks, shaly sandstones, and sandstones carrying a large amount of granitic material. They are generally well drained, free from alkali, and frequently of somewhat refractory nature. They are tilled with difficulty, but possess marked moisture-retaining properties and include large areas of valuable lands devoted to grains, general farm crops, citrus and deciduous fruits, beans, and other special crops. The sandy loam, fine sandy loam, and loam are productive soils, and when irrigated are extensively devoted to citrus fruits, walnuts, olives, prunes, peaches, apricots, grapes, cherries, berries, and vegetables. They frequently occur, however, in extensive elevated areas above the reach of irrigation waters, and under such circumstances are usually devoted to the production of grains by dry farming. The sandy adobe, loam adobe, and clay loam adobe usually occupy sloping plains or an elevated position, are retentive of moisture, well adapted to dry farming of grains, and, when irrigated, to alfalfa, walnuts, and citrus and deciduous fruits.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Placentia series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Placentia sandy loam [a]	California	66,688
fine sandy loam	do	354,333
loam [b]	do	32,904
clay loam	do	2,816
sandy adobe	do	36,454
loam adobe	do	16,320
clay loam adobe	do	8,916
Total		518,431

[a] The soil mapped as Placentia sandy loam in the Ventura area, California, is the Placentia loam, and that mapped as Placentia sandy loam in Lower Salinas Valley, Los Angeles, San Bernardino, San Gabriel, San Jose, and Santa Ana areas, California, is Placentia fine sandy loam.

[b] The soil mapped as Placentia loam in the San Bernardino area, California, is the Placentia clay loam.

Redding series.

The soils of the Redding series are derived from the Red Bluff formation, consisting of ancient alluvial valley deposits. They are of a red to deep-red color, usually gravelly, and sometimes carry large amounts of rounded cobbles, and are underlain by heavy red subsoils and partially indurated clay-iron hardpans, frequently with gravel. They occupy lower rolling foothills and sloping upland dissected plains. The gravelly loam is the prevailing and most important soil in the northern part of the Sacramento Valley, so far as mapped. Where there is not an excess of cobbles or where it is not underlain at shallow depths by hardpan it is well adapted to the production of choice peaches and small fruits. It is not suited to prunes or other deep-rooted trees. Strawberries and bramble fruits yield abundantly, and if irrigated the shallower soils not adapted to tree fruits could be utilized for these small fruits. The hardpan is nearer the surface in the loam than in the gravelly loam. Owing to this fact and its location in unirrigated portions of the valley, it is of secondary agricultural importance, being used principally for grazing or for dry-farmed wheat.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Redding series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Redding loam	California	14,272
gravelly loam	do	57,216
Total		71,488

Sacramento series.

The Sacramento series consists of recent stream deposits ranging in color from light gray in the case of the soils of coarser texture to darker colors in the case of the silty clay loams. The soils are derived from a great variety of rocks, and have been transported long distances, and deposited from shifting river currents or from relatively stagnant flood waters covering flood plains. They are usually 6 feet or more in depth and often subject to overflow when not protected by levees, but when so protected are usually productive and generally adapted to the intensive production of sugar beets, truck crops, or fruits. The Sacramento series is very important, covering a large area and varying widely in texture. The fine sandy loam is the most important prune soil in the Anderson Valley, having played a large part in the development of this industry in that section. It is also a good fruit soil generally, being adapted to peaches, pears, and grapes. Many of the orchards found upon it are in a high state of cultivation. It is also suited to alfalfa and vegetables, and when irrigated sugar beets may be grown upon it. To some extent it is dry-farmed to grain and to hops under intensive cultivation. The silt loam type of this series is devoted chiefly to grazing, but when irrigated it is adapted to alfalfa, sugar beets, and truck, as well as to sorghum and other forage crops. It is also dry-farmed to grain. In some places berries do exceedingly well and it also produces potatoes and hops of excellent quality. Citrus fruits are occasionally found on the silt loam. The gravelly sandy loam type is generally of little agricultural value. The heavier phases are better suited to crops, and when well irrigated will give fair yields of alfalfa and support good orchards. It is sometimes dry-farmed to grain. A very productive type of this series is the silty clay loam, upon which is grown to a considerable extent alfalfa and other forage crops, hops, fruits, and truck crops. In some places it yields excellent citrus fruits, but only to a limited extent. Under irrigation better results are obtained. The silty clay is used chiefly for grazing, but with a moderate amount of water alfalfa and sugar beets may be grown upon it. It is believed that with deep and thorough plowing and frequent cultivation fair yields of corn, sorghum, and other forage crops may be grown without water. When artificially drained and protected from overflow the clay loam type of the Sacramento series is very productive, producing timothy and other grasses, potatoes, onions, beans, etc. The greater part of the loam of this series is devoted to grazing, but when irrigated it is adapted to alfalfa, sugar beets, truck crops, and fruits. It is sometimes dry-farmed.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Sacramento series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Sacramento gravelly sandy loam	California	20,224
fine sandy loam	do	4,224
loam	do	14,144
silt loam [a]	do	17,408
clay loam	do	41,088
silty clay loam	do	50,368
silty clay	do	26,368
Total		173,824

[a] The soil mapped as Sacramento silt loam in the Sacramento area, California, is Hanford silt loam.

Salem series.

The Salem series occurs upon rolling hills as residual soils, upon sloping plains as alluvial and colluvial soils, and upon level valley plains and stream bottoms as recent alluvial deposits. The soils of this series are derived from sandstones, crystalline and schistose rocks, and a dense, highly ferruginous basalt. They are from red to dark brown or black in color, and are generally devoted to grains, fruits, truck crops, and hops. The fine sandy loam and the silt loam are utilized in the production of truck crops, small fruits, and hops, the silt loam being also devoted to grains. They are productive soils and usually well drained, except when subject to overflow. The clay occupies a more elevated position occurring upon rolling and dissected hills. It is usually well drained and devoted to the culture of grains, hops, apples, prunes, and peaches.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Salem series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Salem gravelly loam	Oregon	13,120
fine sandy loam	do	3,648
silt loam	do	78,656
clay	do	86,400
Total		181,824

San Joaquin series.

The soils of the San Joaquin series are of prevailingly red color, frequently gravelly, both gravel and soil particles consisting largely of well-worn quartzose material. They are commonly underlain at a depth of 2 or 3 feet by red or reddish-brown indurated clay or sandy layers cemented by iron salts into a firm, impervious, impenetrable hardpan, which may, however, more deeply underlie the soil or may outcrop at the surface. The reddish color of the soils and subsoils and the occurrence of the underlying red hardpan are readily distinguished characteristics marking this series. The soils are generally of compact structure, sticky, and quite readily puddled when wet and frequently separated from the underlying hardpan by subsoils of true adobe structure. They consist of old sediments deposited in the waters and about the shores of lakes or bays of early Pleistocene age, modified by more recent reworking or by alluvial wash from adjacent formations. They occupy valley plains extending from lower rolling foothills down to level valley floors and margins of present stream flood plains. The areas are usually treeless, except in the immediate vicinity of stream channels. The soils generally occur as extensive areas. The natural drainage is usually restricted by topographic position, deficient slope, and the presence of underlying impermeable hardpan, except in case of the lighter, deeper members and areas occupying higher well-developed slopes. The soils of this series are generally devoted to dry-farming to grains, but the lighter, deeper, and better-drained members are sometimes devoted to citrus and stone fruits, grapes, small fruits, and truck crops, and give excellent yields under proper irrigation, drainage, and cultivation. The heavier members are frequently marked by an adobelike structure. Soils, subsoils, and hardpan are usually free from alkali. The surface is frequently marked by the presence of small "hog wallow" mounds. The soils of the San Joaquin series are dry-farmed to wheat or barley in extensive tracts. The deeper bodies of the sandy loam and the fine sandy loam are, however, adapted, under careful cultivation and irrigation, to the production of the deciduous fruits, strawberries, bramble berries, and grapes, and in the Sacramento area, California, have attained prominence from the development of the strawberry and Tokay grape industries.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the San Joaquin series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
San Joaquin gravelly loam	California	13,376
sand	do	45,696
sandy loam	do	345,587
fine sandy loam	do	32,128
loam	do	77,504
sandy adobe	do	12,691
clay loam adobe	do	3,776
Total		530,758

Sierra series.

The Sierra series comprises residual soils derived through weathering from granitic rocks, diabase, altered rocks, such as amphibolites, slates, serpentine, and volcanic materials, with a slight admixture of colluvial and alluvial material from the same sources. They are prevailingly of light-red to deep-red color, and generally of somewhat compact structure. They are underlain by the bed rocks, sometimes separated from the overlying soil by a thin stratum of adobelike material. The soils are frequently very shallow and marked by abundant rock outcrops, bowlders, and rough, rocky areas unsuitable for agriculture. The soils of this series occupy rolling and frequently mountainous districts and foothills, usually support a more or less heavy growth of brush and forest trees, and are generally well drained. This series covers large areas of valuable fruit and grazing lands along the western slope and base of the Sierra Nevada Mountains in California. The sandy loam is the leading type of this series, and is devoted extensively to the production of peaches, early cherries, citrus fruits, plums, small fruits, and grapes. The clay loam is also well adapted to peaches, cherries, and other deciduous and small fruits, but the soil in local depressions occurring along ravines is frequently cold and wet, and the type is more extensively devoted to grazing and the production of hay and grains. The sandy adobe and the loam adobe are devoted to dry farming of grains, possess well-developed moisture-retaining properties, and when favorably situated are well adapted to the production of grapes with and without irrigation.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Sierra series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Sierra stony loam	California	30,080
sandy loam	do	64,448
clay loam	do	128,183
sandy adobe	do	13,376
loam adobe	do	10,944
Total		247,031

Sites series.

The Sites series consists of residual and colluvial soils of reddish-gray to dark-brown color, derived from sandstones, shales, conglomerates, and volcanic or altered material, occupying lower rolling foothills and their valley slopes. They are usually underlain at shallow depths by sandstones or shaly sandstones, conglomerates or heavy subsoils. The loam and the clay loam adobe are the important soils of this series. They are productive, but owing to their position are generally unirrigable and adapted only to dry-farming to grain.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Sites series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Sites sandy loam	California	960
loam	do	3,200
clay loam adobe	do	34,176
Total		38,336

Stockton series.

The lighter members of this series are a buff to reddish or chocolate-brown color. The heavier members generally exhibit pronounced adobe structure, are usually free from gravel, and are dark-brown to black in color. The soils are underlain by heavy loams or clay loams of lighter color and are frequently separated from the overlying soil by a thin crust or zone of white calcareous clay hardpan free from alkali. They consist in part of alluvium and in part of wash from more elevated adjacent soils and are generally of older origin than the Hanford series. The heavier members have probably been greatly modified by weathering and by the incorporation and decomposition of organic matter resulting from swamp or marsh conditions. This series occupies extensive areas of the lower, nearly level valley plains traversed by minor foothill streams. The soils are treeless or are marked by occasional groves of valley oaks. The drainage is usually restricted. The heavier members are generally tilled with difficulty, owing to their heavy texture and structure, and are generally devoted to grains and hay. The soils of this series are utilized chiefly for the production of grains and hay crops, although apricots, cherries, and deciduous fruits, vines, and vegetables are grown to some extent upon the fine sandy loam and the silt loam, the latter being well adapted to the production of tree fruits and small fruits.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Stockton series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Stockton fine sandy loam	California	12,832
loam	do	26,176
silt loam	do	16,512
loam adobe	do	2,560
clay loam adobe	do	64,446
clay adobe	do	40,832
Total		163,358

Willows series.

The soils of the Willows series are derived mainly from shale and sandstone rocks, and are deposited along the courses and flood plains of minor intermittent foothill streams traversing valley slopes and plains. They are prevailingly of light yellowish-brown or reddish-brown to dark chocolate-brown color. When well drained and free from alkali they are well adapted to the production of alfalfa, grains, and, with the exception of those of extremely heavy texture, to sugar beets. The clay loam of the Willows series is generally free from alkali, and is usually dry-farmed or used for pasture. In favorable locations it is used for alfalfa and grapes, and under irrigation it produces fair crops of sugar beets and good crops of alfalfa. The clay adobe is retentive of moisture, and when well drained and in proper condition it has a friable structure and is easy to cultivate. It is chiefly dry-farmed, and sometimes it will produce a good crop of alfalfa without irrigation, though with irrigation much better results are secured. Under irrigation, sugar beets and general farm crops do well on this type. The loam of the Willows series is generally dry-farmed, but where irrigation is practiced it is well adapted to alfalfa and vine, tree, and cane fruits. In favorable seasons very fair crops of wheat and barley are produced by dry-farming on the silty clay type, and under irrigation alfalfa and sugar beets do well. The clay type of this series generally contains alkali, and is cultivated with difficulty, owing to poor drainage. It is therefore best adapted to grazing. With proper drainage it may be reclaimed, and would then be suited to various crops.

The acreage of the types so far encountered is as follows:

Area and distribution of the soils of the Willows series.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Willows loam	California	5,568
silty clay loam	do	24,896
clay loam	do	60,480
clay adobe	do	95,488
clay	do	40,640
Total		227,072

Miscellaneous soils of the Pacific coast.

Meadow comprises low-lying, flat, and poorly drained land of variable texture. Frequently of some value for grass and pasturage. Much more of it can be reclaimed by simple methods of drainage, and when this is done excellent results can be secured from a variety of crops.

The Muck and Peat are composed largely of organic matter in various conditions of decay, the Muck representing an advanced stage of change in Peat areas. Of relatively limited extent and poorly drained, these soils are highly valued for their adaptation to special crops, such as celery, onions, peppermint, and cabbage.

The Norman clay adobe with irrigation, drainage, and thorough cultivation should be capable of producing alfalfa, grains, and the general farm crops. At present it is used for grazing and for dry-farming.

The Orland fine sandy loam, occurring in the Sacramento Valley, California, is mainly utilized at present in the production of dry-farmed grains, but should, when placed under irrigation, become of much higher value than at present if devoted to the production of alfalfa, fruits, vegetables, and sugar beets.

The Orland fine sand occurs along streams and is subject to overflow. When protected by dikes it is well adapted to alfalfa, vegetables, and fruits.

The Puget clay and Puget fine sandy loam have deficient drainage, but when drained and protected from overflow truck crops and potatoes are successfully grown.

The Puget silt loam is utilized in the production of potatoes, berries, hops, and oats, and gives promise of becoming a highly prized soil in the small-fruit and vegetable producing industries.

The Salinas gray adobe covers extensive areas in the coastal valleys of California and is utilized mainly in the production of sugar beets or dry-farmed to grains.

Sandhill, Dunesand, and Coastal beach are deep sands of little agricultural value.

The Santiago fine sandy loam covers a considerable area in the Santa Ana area, California, and is devoted principally to dry-farming of wheat and barley.

Tidal swamp and marsh are areas covered with water the greater part of the year and unfit for agriculture.

The other miscellaneous soils are of limited acreage and minor agricultural importance.

The acreage of the types so far encountered is as follows:

Area and distribution of the miscellaneous soils of the Pacific coast.

Soil name.	States in which each type has been found.	Total area.
		Acres.
Bellavista sandy loam	California	3,328
Meadow	do	5,478
Muck and Peat	do	110,163
Norman clay adobe	do	6,208
Orland fine sand	do	1,856
Orland fine sandy loam	do	7,168
Puget clay	Washington	33,984
Puget fine sandy loam	do	18,816
Puget silt loam	do	22,080
Rock outcrop and Riverwash	California	115,393
Salinas gray adobe[a]	do	64,544
Sandhill, Dunesand, and Coastal beach	California, Washington	132,452
Santiago fine sandy loam	California	17,100
Santiago loam	do	1,830
Sheridan sandy loam	do	1,792
Tidal swamp and marsh	California, Washington	31,168
Total		573,680

[a] The soil mapped as Salinas gray adobe in the Sacramento area, California, is Hanford clay adobe.

AREA OF SOILS SURVEYED IN THE SEVERAL STATES.

The following table gives the distribution of the soils surveyed up to January 1, 1908, in the several States:

Area of soils surveyed in the several States, arranged in provinces and series.

ALABAMA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Glenn sandy loam		73,600	
loam		35,584	
Greenville fine sandy loam		9,152	
Guin stony sandy loam	28,032		
gravelly sandy loam	69,056		
fine sandy loam	181,824		
		278,912	
Houston clay	450,216		
black clay	26,648		
		476,864	
Lufkin clay		102,016	
Mobile clay		896	
Myatt fine sand	21,376		
fine sandy loam	41,536		
		62,912	
Norfolk gravelly loam	88,832		
coarse sand	100,160		
sand	212,608		
fine sand	61,184		
sandy loam	81,600		
fine sandy loam	305,664		
loam	61,824		
silt loam	17,216		
clay	95,168		
		1,024,256	
Orangeburg sand	66,624		
fine sand	47,616		
sandy loam	136,448		
fine sandy loam	585,536		
clay	175,808		
		1,012,032	
Susquehanna gravelly loam	7,424		
fine sandy loam	147,072		
clay	184,000		
		338,496	
Warsaw sandy loam		33,408	
			3,448,128
River flood plains:			
Chattooga loam		5,696	
Congaree loam	33,856		
clay	16,512		
		50,368	
Huntington silt loam		39,424	
Meadow		294,656	
Ocklocknee sand	960		
fine sandy loam	28,544		
clay	29,824		
		59,328	
Swamp		8,192	
Wabash silt loam	49,792		
clay	50,624		
		100,416	
Waverly loam	100,288		
clay	11,840		
		112,128	
			670,208
Piedmont Plateau:			
Cecil stony loam	69,056		
stony clay	17,856		
sandy loam	155,584		
clay	9,536		
		252,032	
Rough stony land		4,928	
			256,960

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

ALABAMA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
	Acres.	*Acres.*	*Acres.*
Appalachian Mountains and Plateau:			
Chandler stony loam		1,664	
Dekalb stony loam	37,120		
sandy loam	351,168		
fine sandy loam	95,744		
silt loam	17,280		
clay	77,952		
		579,264	
Lickdale stony loam		4,416	
Montevallo stony loam		4,032	
Rough stony land		49,344	
Talladega stony loam		15,552	
slate loam		95,552	
Upshur sandy loam	8,896		
loam	14,720		
		23,616	
			773,440
Limestone valleys and uplands:			
Clarksville stony loam	432,128		
gravelly sandy loam	5,376		
fine sandy loam	1,856		
loam	6,272		
silt loam	163,840		
		609,472	
Cumberland fine sandy loam		4,864	
Decatur stony loam	85,696		
loam	25,664		
clay loam	56,064		
		167,424	
Guthrie silt loam		320	
clay		15,424	
Hagerstown stony loam	41,984		
stony clay	6,848		
sandy loam	8,064		
loam	221,568		
clay	12,992		
		291,456	
			1,088,960
Total for State			6,237,696

ARIZONA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Arid Southwest:			
Gila fine sand	27,144		
fine sandy loam	43,794		
loam	35,136		
silt loam	9,408		
clay loam	23,424		
clay	13,655		
		152,561	
Glendale clay loam		52,040	
Rough stony land and Riverwash		8,140	
Yuma sand		94,400	
			307,141
Pacific coast:			
Maricopa gravelly loam	51,066		
sand	20,480		
sandy loam	10,368		
fine sandy loam	106,906		
loam	33,514		
silt loam	11,648		
clay loam	8,713		
		242,695	
			242,695
Total for State			549,836

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

ARKANSAS.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Acadia silt loam		136,512	
Crowley silt loam		232,960	
Morse clay		5,760	
Orangeburg fine sandy loam		224,640	
			599,872
River flood plains:			
Biscoe silt loam		12,992	
Calhoun clay		12,672	
Collins silt loam		8,576	
Miller fine sand	34,688		
fine sandy loam	28,544		
clay	110,656		
		173,888	
Meadow		1,536	
Swamp		2,240	
Wabash fine sand	4,480		
fine sandy loam	10,112		
loam	6,464		
silt loam	48,192		
clay loam	11,584		
clay	23,040		
		103,872	
Waverly silt loam	44,672		
clay	98,688		
		143,360	
			459,136
Appalachian Mountains and Plateau:			
Conway silt loam		38,912	
Fayetteville stony loam	118,400		
fine sandy loam	17,216		
loam	44,352		
		179,968	
Rough stony land		104,000	
Upshur stony loam	23,232		
fine sandy loam	17,472		
loam	12,160		
		52,864	
			375,744
Limestone valleys and uplands:			
Clarksville stony loam	145,472		
silt loam	90,880		
		236,352	
Guthrie clay		27,904	
			264,256
Residual soils of the western prairie:			
Gasconade silt loam			14,720
Total for State			1,713,728

CALIFORNIA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Arid Southwest:	*Acres.*	*Acres.*	*Acres.*
Gila fine sand	1,088		
loam	44,096		
silt loam	3,264		
clay loam	960		
clay	4,096		
		53,504	
Imperial sand	1,792		
sandy loam	126,656		
clay loam	341,056		
clay	46,912		
		516,416	
Indio gravelly loam	43,328		
sand	50,112		
fine sand	36,032		
fine sandy loam	42,432		
		171,904	
			741,824
Pacific coast:			
Anderson gravelly loam	14,528		
fine sandy loam	3,520		
		18,048	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

CALIFORNIA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
	Acres.	*Acres.*	*Acres.*
Pacific coast—Continued.			
Bellavista sandy loam		3,328	
Dunesand		129,828	
Fresno sand	193,526		
fine sand	8,128		
sandy loam	5,952		
fine sandy loam	90,975		
loam	5,824		
		304,405	
Hanford gravel	4,544		
sand	224,680		
fine sand	118,338		
sandy loam	19,860		
fine sandy loam	151,194		
silt loam	73,137		
clay loam	17,896		
clay adobe	12,672		
		622,321	
Maricopa gravelly sand	194,886		
gravelly loam	47,160		
sand	7,838		
sandy loam	37,312		
fine sandy loam	5,952		
		293,148	
Meadow		5,478	
Norman clay adobe		6,208	
Orland fine sand		1,856	
Orland fine sandy loam		7,168	
Oxnard gravelly loam	16,270		
sand	56,520		
sandy loam	75,600		
fine sandy loam	22,848		
loam	19,812		
silt loam	31,240		
clay loam	30,574		
clay loam adobe	134,598		
		387,462	
Peat		110,163	
Placentia sandy adobe	36,454		
sandy loam	66,688		
fine sandy loam	354,333		
loam	32,904		
loam adobe	16,320		
clay loam	2,816		
clay loam adobe	8,916		
		518,431	
Redding gravelly loam	57,216		
loam	14,272		
		71,488	
Rough stony land and Riverwash		115,393	
Sacramento gravelly sandy loam	20,224		
fine sandy loam	4,224		
loam	14,144		
silt loam	17,408		
silty clay loam	50,368		
clay loam	41,088		
silty clay	26,368		
		173,824	
Salinas gray adobe		64,544	
San Joaquin gravelly loam	13,376		
sand	45,696		
sandy adobe	12,691		
sandy loam	345,587		
fine sandy loam	32,128		
loam	77,504		
clay loam adobe	3,776		
		530,758	
Santiago fine sandy loam		17,100	
Santiago loam		1,830	
Sheridan sandy loam		1,792	
Sierra stony loam	30,080		
sandy adobe	13,376		
sandy loam	64,448		
loam adobe	10,944		
clay loam	128,183		
		247,031	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

CALIFORNIA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Pacific coast—Continued.	*Acres.*	*Acres.*	*Acres.*
Sites sandy loam	960		
loam	3,200		
clay loam adobe	34,176		
		38,336	
Stockton fine sandy loam	12,832		
loam	26,176		
loam adobe	2,560		
silt loam	16,512		
clay loam adobe	64,416		
clay adobe	40,832		
		163,358	
Tidal swamp and marsh		30,848	
Willows loam	5,568		
silty clay loam	24,896		
clay loam	60,480		
clay	40,640		
clay adobe	95,488		
		227,072	
			4,091,218
Total for State			4,833,042

COLORADO.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial and loessial:	*Acres.*	*Acres.*	*Acres.*
Marshall silt loam			236,288
Rocky Mountain valleys and plains:			
Billings fine sandy loam	26,944		
loam	41,984		
silt loam	9,664		
clay loam	16,128		
clay	5,760		
		100,480	
Colorado gravelly loam	33,408		
sand	128,576		
sandy loam	156,096		
fine sandy loam	196,480		
loam	78,784		
loam adobe	42,880		
clay loam	832		
		637,056	
Dunesand		3,328	
Fort Collins loam		14,144	
Fruita fine sandy loam	3,968		
loam	512		
		4,480	
Laurel fine sand	8,960		
sandy loam	72,640		
loam	37,760		
clay loam	23,104		
		142,464	
Mesa fine sandy loam	34,432		
clay loam	2,240		
clay	22,464		
		59,136	
Riverwash		12,800	
San Luis sand	136,960		
sandy loam	196,992		
loam	9,088		
		343,040	
Swamp		640	
			1,317,568
Total for State			1,553,856

CONNECTICUT.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		33,814	
Swamp		24,912	
			58,726

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

CONNECTICUT—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Piedmont Plateau:	*Acres.*	*Acres.*	*Acres.*
Penn stony loam			85,080
Glacial and loessial:			
Holyoke stony loam			5,056
Glacial lake and river terraces:			
Elmwood loam		12,280	
Enfield sandy loam		32,534	
Manchester sandy loam		19,520	
Merrimac gravelly sandy loam	4,096		
coarse sand	19,196		
coarse sandy loam	18,816		
sandy loam	54,900		
		97,008	
Podunk fine sandy loam		2,016	
Suffield clay		11,154	
			174,512
Total for State			323,374

DELAWARE.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Coastal beach		64	
Elkton silt loam		6,016	
Norfolk sand	5,632		
loam	66,752		
silt loam	32,960		
		105,344	
Portsmouth sand	640		
sandy loam	50,304		
		50,944	
Tidal swamp and marsh		30,784	
			193,152
River flood plains:			
Meadow		4,096	
Swamp		3,712	
			7,808
Total for State			200,960

FLORIDA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Gadsden sand	49,856		
sandy loam	6,592		
		56,448	
Gainesville sand		7,744	
Leon sand		61,376	
Leon fine sand		17,728	
Muck		128	
Myatt fine sandy loam		5,696	
Norfolk sand	636,736		
fine sand	48,448		
sandy loam	175,424		
fine sandy loam	214,912		
very fine sandy loam	768		
loam	17,536		
		1,093,824	
Orangeburg sand	51,968		
sandy loam	17,024		
fine sandy loam	140,736		
loam	1,280		
		211,008	
Portsmouth sand	40,064		
fine sand	93,824		
sandy loam	40,384		
fine sandy loam	6,016		
		180,288	
Sandhill and Coastal beach		52,928	
Swamp and Marsh		60,352	
			1,747,520

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

FLORIDA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
	Acres.	*Acres.*	*Acres.*
River flood plains:			
Meadow		137,152	
Ocklocknee clay		3,712	
Swamp		2,816	
			143,680
Total for State			1,891,200

GEORGIA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Gadsden sand		7,488	
Norfolk coarse sand	12,416		
sand	266,688		
fine sand	27,776		
sandy loam	160,576		
fine sandy loam	128,064		
clay	640		
		596,160	
Orangeburg sand	22,592		
fine sandy loam	61,376		
clay	31,168		
		115,136	
Portsmouth sand	3,456		
fine sand	205,568		
fine sandy loam	43,840		
		252,864	
Sandhill		5,888	
Swamp		26,944	
			1,004,480
River flood plains:			
Meadow		105,506	
Ocklocknee clay		832	
			106,338
Piedmont Plateau:			
Cecil sand	448		
sandy loam	105,134		
clay	332,620		
		438,202	438,202
Appalachian Mountains and Plateau:			
Porters stony loam			2,020
Total for State			1,551,040

IDAHO.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Northwestern intermountain region:	*Acres.*	*Acres.*	*Acres.*
Boise loam		61,960	
Boise silt loam		95,850	
Deer Flat fine sandy loam		45,380	
Gallatin fine sandy loam	35,212		
loam	241,216		
silt loam	17,436		
		293,864	
Meadow		1,600	
Riverwash		1,792	
Yakima sand	48,448		
fine sand	17,430		
sandy loam	29,760		
fine sandy loam	31,872		
loam	18,944		
silt loam	172,992		
		319,446	
			819,892
Total for State			819,892

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

ILLINOIS.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Lintonia loam		5,696	
Meadow		47,872	
Wabash loam	29,056		
silt loam	125,276		
clay	54,656		
		208,988	
Waverly fine sandy loam	1,344		
silt loam	137,600		
clay loam	128		
		139,072	
Yazoo sandy loam		15,104	
Yazoo loam		7,040	
			423,772
Glacial and loessial:			
Marion silt loam		519,488	
Marshall sandy loam	84,160		
loam	17,984		
silt loam	1,450,560		
black clay loam	224,384		
		1,777,088	
Memphis silt loam		305,856	
Miami gravel	6,272		
fine sand	36,544		
silt loam	616,064		
		658,880	
Rough stony land		23,360	
			3,284,672
Glacial lake and river terraces:			
Muck and Peat		3,840	
Sioux sandy loam	38,528		
loam	32,512		
silt loam	25,600		
		96,640	
			100,480
Total for State			3,808,924

INDIANA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Norfolk fine sandy loam		22,848	
			22,848
River flood plains:			
Griffin clay		1,600	
Huntington fine sandy loam	13,696		
loam	31,040		
silt loam	16,512		
		61,248	
Lintonia loam		9,408	
Meadow		17,600	
Riverwash		1,024	
Wabash sandy loam	2,624		
fine sandy loam	15,296		
silt loam	26,624		
		44,544	
Waverly fine sandy loam	9,920		
loam	8,320		
silt loam	62,592		
clay loam	44,800		
clay	39,040		
		164,672	
Yazoo sandy loam		2,752	
			302,848
Appalachian Mountains and Plateau:			
Dekalb silt loam			22,080
Glacial and loessial:			
Bloomfield sandy loam		10,944	
Madison loam		2,240	
Marshall sand	20,672		
fine sand	9,792		
sandy loam	77,184		
fine sandy loam	54,144		
loam	275,392		
silt loam	142,854		
black clay loam	41,408		
		621,446	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

INDIANA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial and loessial—Continued.	*Acres.*	*Acres.*	*Acres.*
Miami gravelly sandy loam	2,240		
gravelly loam	576		
sand	36,032		
sandy loam	512		
fine sand	35,520		
fine sandy loam	4,608		
loam	26,688		
silt loam	504,832		
clay loam	424,704		
		1,035,712	
Rough stony land		18,432	
Scottsburg silt loam		37,184	
Volusia silt loam		46,912	
			1,772,870
Glacial lake and river terraces:			
Clyde fine sand	61,056		
sandy loam	11,712		
loam	960		
clay	6,144		
		79,872	
Marco fine sandy loam		3,392	
Marco clay loam		3,200	
Muck and Peat		40,832	
Newton fine sand		5,888	
Sioux sandy loam	9,344		
loam	896		
silt loam	570		
		10,810	
Swamp		3,648	
			147,642
Total for State			2,268,288

IOWA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		22,592	
Wabash silt loam		91,520	
			114,112
Glacial and loessial:			
Marshall sand	1,024		
fine sand	3,072		
loam	547,648		
silt loam	308,288		
clay loam	75,840		
black clay loam	25,984		
		961,856	
Miami fine sand	3,968		
sandy loam	15,040		
silt loam	244,736		
clay loam	13,376		
		277,120	
Rough stony land		55,744	
			1,294,720
Glacial lake and river terraces:			
Muck		12,096	
Sioux sandy loam		32,768	
			44,864
Total for State			1,453,696

KANSAS.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Houston clay			35,456
River flood plains:			
Neosho silt loam		30,739	
Wabash silt loam	85,184		
silt clay	4,992		
clay	37,107		
		127,283	
Yazoo sandy loam		909	
Yazoo loam		48,883	
			207,814

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

KANSAS—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
	Acres.	*Acres.*	*Acres.*
Glacial and loessial:			
Marshall gravelly loam	10,176		
sandy loam	2,240		
silt loam	515,840		
		528,256	
Miami sand	19,392		
fine sand	15,744		
		35,136	
Rough stony land		17,088	
			580,480
Residual soils of the western prairie:			
Crawford gravelly loam	5,165		
silt loam	211,559		
clay	68,544		
		285,268	
Derby loam		20,416	
Oswego fine sandy loam	25,293		
silt loam	462,848		
		488,141	
Rock outcrop and Rough stony land		120,793	
Sedgwick black clay loam		5,568	
			920,186
Rocky Mountain valleys and plains:			
Colorado sand	10,944		
sandy loam	27,200		
loam	47,040		
		85,184	
Dunesand		83,200	
Finney sandy loam	6,272		
clay	2,240		
		8,512	
Laurel fine sand	2,112		
sandy loam	16,000		
fine sandy loam	13,888		
loam	54,272		
loam adobe	1,472		
silt loam	17,600		
		105,344	
Rough stony land		8,768	
			291,008
Total for State			2,034,944

KENTUCKY.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Leonardtown loam		320	
Norfolk fine sandy loam	3,008		
loam	896		
		3,904	
Portsmouth silt loam		896	
			5,120
River flood plains:			
Lintonia loam		17,984	
Meadow		832	
Muck		320	
Riverwash		128	
Wabash silt loam	45,440		
		45,440	
Waverly fine sandy loam	3,072		
silt loam	5,824		
clay	38,016		
		46,912	
			111,616
Appalachian Mountains and Plateau:			
Dekalb shale loam	18,880		
fine sandy loam	832		
loam	20,800		
silt loam	120,832		
		161,344	
Rough stony land		3,904	
			165,248
Limestone valleys and uplands:			
Clarksville silt loam	232,832		
clay loam	9,408		
		242,240	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

KENTUCKY—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Limestone valleys and uplands—Continued.	*Acres.*	*Acres.*	*Acres.*
Cumberland loam		4,288	
Guthrie clay		4,480	
Hagerstown stony clay	33,792		
loam	208,256		
clay	261,568		
		503,616	
			754,624
Glacial and loessial:			
Memphis silt loam		139,776	
Miami silt loam		154,176	
			293,952
Total for State			1,330,560

LOUISIANA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Acadia silt loam		89,280	
Amite sandy loam		7,232	
Amite loam		16,320	
Caddo fine sandy loam		142,528	
Calcasieu fine sand		13,970	
Calcasieu fine sandy loam		5,500	
Calcasieu loam		51,280	
Crowley silt loam		244,160	
Greenville gravelly sandy loam		10,752	
Greenville loam		2,048	
Hammond silt loam		70,976	
Houston clay		1,728	
Lacasine clay loam		3,470	
Lake Charles fine sandy loam		143,924	
Lake Charles loam		6,378	
Landry silt loam		37,696	
Lufkin clay		5,440	
Monroe silt loam		236,096	
Morse clay		1,664	
Myatt fine sandy loam		8,064	
Norfolk sand	1,600		
fine sand	23,040		
fine sandy loam	550,720		
		575,360	
Orangeburg sand	4,544		
fine sand	54,336		
sandy loam	1,280		
fine sandy loam	300,032		
		360,192	
Peat		59,200	
Susquehanna fine sandy loam	348,544		
clay loam	14,080		
clay	45,696		
		408,320	
Swamp, Tidal swamp and marsh		10,304	
			2,511,882
River flood plains:			
Meadow		316,288	
Miller fine sand	16,960		
fine sandy loam	110,976		
silt loam	23,296		
clay	99,200		
		250,432	
Muck		21,056	
Sharkey clay		243,648	
Swamp		13,248	
Wabash clay	41,088		
		41,088	
Yazoo sandy loam		43,136	
Yazoo loam		19,584	
			948,480
Glacial and loessial:			
Marshall silt loam		16,640	
Memphis silt loam		219,200	
			235,840
Total for State			3,696,202

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

MARYLAND.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Coastal beach		8,064	
Collington sandy loam		23,260	
Elkton sandy loam	9,280		
loam	2,624		
silt loam	140,524		
		152,428	
Leonardtown loam		152,930	
Norfolk gravel	123,740		
coarse sand	65,370		
sand	234,272		
fine sand	58,590		
fine sandy loam	23,380		
loam	88,078		
silt loam	196,050		
		789,480	
Portsmouth sand	41,024		
sandy loam	37,696		
loam	2,944		
		81,664	
Sassafras gravelly loam	2,880		
sand	29,696		
loamy sand	52,992		
sandy loam	160,576		
fine sandy loam	18,496		
loam	101,760		
silt loam	130,944		
		497,344	
Susquehanna clay loam	16,850		
clay	38,250		
		55,100	
Swamp, Tidal swamp and marsh		69,200	
			1,829,470
River flood plains:			
Meadow		176,620	
Swamp		2,200	
			178,820
Piedmont Plateau:			
Cardiff slate loam		1,690	
Cecil clay		52,838	
Chester mica loam	51,938		
loam	171,624		
		223,562	
Conowingo barrens		5,280	
Conowingo clay		9,510	
Loudoun sandy loam		768	
Penn gravelly loam	192		
loam	1,344		
clay	2,240		
		3,776	
			297,424
Appalachian Mountains and Plateau:			
Dekalb stony loam	1,600		
shale loam	192		
		1,792	
			1,792
Total for State			2,307,506

MASSACHUSETTS.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		41,038	
Swamp		14,774	
			55,812
Piedmont Plateau:			
Penn stony loam			24,036
Glacial and loessial:			
Bernardstown loam		16,064	
Holyoke stony loam		191,762	
			207,826
Glacial lake and river terraces:			
Elmwood loam		6,598	
Enfield sandy loam		13,928	
Manchester sandy loam		24,640	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

MASSACHUSETTS—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial lake and river terraces—Continued.	*Acres.*	*Acres.*	*Acres.*
Merrimac gravelly sandy loam	55,188		
coarse sandy loam	9,088		
coarse sand	52,812		
sandy loam	40,404		
		157,492	
Podunk fine sandy loam		15,268	
Suffield clay		12,456	
			230,382
Total for State			518,056

MICHIGAN.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		53,462	
Wabash loam		1,152	
			54,614
Limestone valleys and uplands:			
Fort Payne sandy loam			7,936
Glacial and loessial:			
Marshall loam	20,544		
black clay loam	13,056		
		33,600	
Miami stony sand	5,622		
stony loam	80,310		
gravelly sand	57,642		
gravelly sandy loam	27,840		
gravelly loam	1,088		
sand	474,824		
fine sand	64,460		
sandy loam	249,780		
fine sandy loam	119,360		
loam	103,296		
clay loam	271,242		
		1,455,464	
Rough stony land		17,344	
			1,506,408
Glacial lake and river terraces:			
Clyde stony sandy loam	8,000		
gravelly sand	24,656		
sand	67,400		
sandy loam	98,304		
fine sandy loam	40,704		
loam	386,476		
silt loam	3,904		
clay	26,560		
		656,004	
Dunesand		10,554	
Elmwood loam		3,810	
Muck		143,658	
Saginaw sandy loam		14,272	
Saugatuck sand		24,120	
Superior clay		704	
Swamp and Marsh		2,752	
			855,874
Total for State			2,424,832

MINNESOTA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		24,960	
Wabash fine sandy loam	14,528		
loam	3,968		
silt loam	13,312		
		31,808	
			56,768
Glacial and loessial:			
Barnum stony loam		8,704	
Barnum loam		2,496	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

MINNESOTA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial and loessial—Continued.	*Acres.*	*Acres.*	*Acres.*
Judson loam		3,968	
Marshall gravel	1,216		
gravelly loam	960		
fine sand	15,872		
sandy loam	4,480		
fine sandy loam	13,824		
loam	117,120		
silt loam	128,704		
clay loam	185,152		
black clay loam	29,760		
		497,088	
Miami stony loam	50,560		
gravelly sandy loam	5,184		
sand	17,408		
fine sand	1,920		
sandy loam	54,784		
		129,856	
Rock outcrop and Rough stony land		19,264	
			661,376
Glacial lake and river terraces:			
Benoit fine sandy loam		4,032	
Benoit loam		31,360	
Dunesand		1,024	
Fargo fine sandy loam	93,312		
silt loam	20,032		
clay loam	344,576		
clay	27,968		
		485,888	
Mankato sand		4,032	
Mankato sandy loam		2,816	
Mankato loam		1,600	
McLeod sand		4,288	
Muck and Peat		33,344	
Sioux gravelly sandy loam		24,448	
Superior silt loam	16,192		
clay	43,392		
		59,584	
			652,416
Total for State			1,370,560

MISSISSIPPI.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Gadsden loam		14,592	
Guin fine sandy loam		176,192	
Houston chalk	8,064		
clay	38,400		
		46,464	
Lufkin silt loam	55,808		
clay	71,040		
		126,848	
Monroe silt loam		64,896	
Montrose sandy loam	20,928		
clay	43,840		
		64,768	
Myatt fine sandy loam	6,144		
clay loam	4,096		
		10,240	
Norfolk gravelly loam	48,768		
coarse sand	448		
sand	77,568		
fine sand	57,216		
sandy loam	16,128		
fine sandy loam	374,464		
loam	83,264		
		657,856	
Oktibbeha fine sandy loam	17,344		
silt loam	13,824		
clay loam	15,360		
clay	25,920		
		72,448	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

MISSISSIPPI—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains—Continued.	*Acres.*	*Acres.*	*Acres.*
Orangeburg sand	6,656		
fine sand	2,304		
sandy loam	81,856		
fine sandy loam	166,400		
loam	1,984		
clay	98,368		
		357,568	
Portsmouth loam		3,328	
Susquehanna fine sandy loam	6,080		
silt loam	9,984		
clay	31,360		
		47,424	
			1,642,624
River flood plains:			
Catalpa silt loam		5,056	
Congaree loam		53,760	
Lintonia loam		54,452	
Meadow		131,992	
Neuse clay		13,120	
Ocklocknee loam	103,360		
clay loam	13,632		
clay	55,552		
		172,544	
Sharkey clay		333,820	
Swamp		3,072	
Wabash clay		90,456	
Waverly fine sandy loam	3,840		
loam	8,960		
silt loam	49,152		
clay	7,360		
		69,312	
Yazoo sandy loam		35,182	
Yazoo loam		36,368	
			999,134
Glacial and loessial:			
Memphis silt loam			775,866
Total for State			3,417,624

MISSOURI.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Jackson loam		2,304	
Meadow		40,000	
Riverwash		1,856	
Wabash loam	11,904		
silt loam	186,944		
clay	59,904		
		258,752	
Waverly silt loam	49,664		
clay loam	23,296		
		72,960	
Yazoo loam		30,912	
			406,784
Appalachian Mountains and Plateau:			
Dekalb fine sandy loam			3,584
Limestone valleys and uplands:			
Clarksville silt loam	365,376		
stony loam	1,044,160		
		1,409,536	
Rough stony land		3,200	
			1,412,736
Glacial and loessial:			
Marion silt loam		175,552	
Marshall silt loam		306,816	
Memphis silt loam		5,184	
Miami fine sand	640		
silt loam	74,432		
		75,072	
Rough stony land		28,160	
Shelby sand		448	
Shelby loam		410,368	
Shelby silt loam		402,112	
			1,403,712

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

MISSOURI—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial lake and river terraces:	*Acres.*	*Acres.*	*Acres.*
Sioux sandy loam			320
Residual soils of the western prairie:			
Gasconade silt loam			1,600
Total for State			3,228,736

MONTANA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Northwestern intermountain region:	*Acres.*	*Acres.*	*Acres.*
Bozeman silt loam		76,608	
Bridger gravelly loam	12,544		
clay loam	1,472		
		14,016	
Gallatin gravelly loam	32,576		
fine sandy loam	6,464		
silt loam	23,808		
clay loam	896		
		63,744	
Yakima silt loam		53,824	
			208,192
Rocky Mountain valleys and plains:			
Billings gravelly loam	11,776		
fine sandy loam	13,568		
clay loam	14,144		
clay	17,088		
		56,576	
Laurel sandy loam		8,832	
Swamp		3,008	
			68,416
Total for State			276,608

NEBRASKA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		28,544	
Muck		3,264	
Sarpy clay loam		2,816	
Wabash fine sandy loam	22,144		
silt loam	131,264		
clay	3,648		
		157,056	
			191,680
Glacial and loessial:			
Marshall fine sandy loam	15,424		
fine sand	21,440		
loam	142,144		
silt loam	964,864		
		1,143,872	
Miami sand	29,440		
fine sand	56,576		
silt loam	69,696		
		155,712	
			1,299,584
Glacial lake and river terraces:			
Sioux sandy loam	29,184		
fine sandy loam	60,352		
		89,536	
			89,536
Rocky Mountain valleys and plains:			
Dunesand		161,664	
Finney fine sandy loam	40,128		
loam	11,008		
		51,136	
Gannett fine sand		8,448	
Lancaster fine sandy loam		2,368	
Laurel gravelly loam	16,448		
fine sand	5,440		
sandy loam	10,048		
fine sandy loam	5,760		
loam	24,768		
		62,464	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

NEBRASKA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Rocky Mountain valleys and plains—Continued.	*Acres.*	*Acres.*	*Acres.*
Meadow		46,272	
North Platte loam		23,936	
Osgood fine sandy loam		16,320	
Rough stony land and Riverwash		40,000	
			412,608
Total for State			1,993,408

NEW HAMPSHIRE.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow			14,848
Glacial and loessial:			
Gloucester stony sandy loam		67,904	
Gloucester stony loam		80,192	
Rock outcrop and Rough stony land		323,008	
			471,104
Glacial lake and river terraces:			
Merrimac coarse sand	13,824		
sand	26,560		
gravelly sandy loam	50,240		
		90,624	
Podunk fine sandy loam		12,928	
Podunk silt loam		960	
			104,512
Total for State			590,464

NEW JERSEY.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Alloway clay		22,484	
Collington sandy loam		87,626	
Elkton silt loam		11,240	
Norfolk gravel	192		
coarse sand	18,792		
sand	129,290		
fine sand	31,134		
sandy loam	25,430		
silt loam	194,412		
		399,250	
			520,600
River flood plains:			
Meadow			95,770
Piedmont Plateau:			
Cecil stony loam		13,952	
Penn stony loam	5,632		
sandy loam	10,816		
loam	171,712		
		188,160	
			202,112
Total for State			818,482

NEW MEXICO.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Arid Southwest:	*Acres.*	*Acres.*	*Acres.*
Gila fine sand		2,810	
Gypsum		11,630	
Meadow		7,940	
Pecos conglomerate		11,680	
Pecos sandy loam		36,310	
Roswell fine sandy loam		9,090	
Roswell loam		2,730	
Total for State			82,190

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

NEW YORK.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Coastal beach		12,224	
Hempstead loam		53,824	
Norfolk gravel	3,328		
coarse sand	1,856		
sand	77,120		
coarse sandy loam	64,896		
loam	100,096		
		247,296	
Tidal swamp and marsh		52,800	
			366,144
River flood plains:			
Huntington loam	24,640		
silt loam	11,200		
		35,840	
Meadow		100,670	
Wabash loam		39,872	
			176,382
Appalachian Mountains and Plateau:			
Dekalb clay		21,860	
Upshur clay		7,936	
			29,796
Glacial and loessial:			
Allis shale loam		2,368	
Allis clay		2,304	
Cassadaga sand		1,660	
Dover fine sandy loam		8,512	
Dover loam		28,800	
Dutchess stony loam		51,776	
Dutchess slate loam		94,144	
Dutchess silt loam		117,184	
Gloucester stony loam		8,256	
Gloucester loam		10,752	
Madeland		1,024	
Miami stony sand	5,376		
stony sandy loam	163,008		
stony loam	509,056		
fine sand	31,936		
fine sandy loam	6,848		
		716,224	
Rhinebeck loam		1,088	
Rock outcrop and Rough stony land		140,736	
Volusia stony loam	12,352		
gravelly loam	4,608		
loam	291,234		
silt loam	444,608		
clay loam	5,952		
		758,754	
			1,943,582
Glacial lake and river terraces:			
Clyde fine sand	320		
fine sandy loam	20,224		
loam	55,360		
clay	18,752		
		94,656	
Dunkirk stony clay	35,072		
gravel	4,840		
gravelly sandy loam	31,004		
gravelly loam	98,432		
shale loam	14,592		
fine sand	10,944		
sandy loam	4,480		
fine sandy loam	105,674		
loam	144,832		
silt loam	94,272		
clay loam	107,264		
clay	121,666		
		773,072	
Hudson sandy loam	1,856		
fine sandy loam	6,400		
loam	3,904		
clay loam	9,984		
		22,144	
Lockport clay		6,656	
Merrimac gravelly loam	41,216		
gravelly sandy loam	9,600		
loam	1,600		
		52,416	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

NEW YORK—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial lake and river terraces—Continued.	*Acres.*	*Acres.*	*Acres.*
Muck and Peat		45,568	
Podunk fine sandy loam		192	
Swamp		14,272	
Tonawanda loam		15,168	
Vergennes stony loam	2,752		
gravelly loam	2,944		
fine sand	6,272		
sandy loam	128		
loam	2,048		
clay	27,904		
		42,048	
Warners loam		128	
			1,066,320
Total for State			3,582,224

NORTH CAROLINA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Muck		6,230	
Norfolk gravel	11,410		
coarse sand	384		
sand	88,958		
fine sand	266,304		
sandy loam	362,524		
fine sandy loam	592,388		
silt loam	12,992		
clay	9,600		
		1,344,560	
Orangeburg fine sandy loam		7,616	
Portsmouth sand	49,088		
fine sand	28,608		
sandy loam	89,124		
fine sandy loam	150,436		
loam	105,152		
silt loam	126,272		
		548,680	
Sandhill and Coastal beach		23,432	
Susquehanna gravelly loam		14,330	
Swamp, Tidal swamp and marsh		388,650	
			2,333,498
River flood plains:			
Meadow		84,010	
Neuse clay		4,832	
Swamp		38,288	
Toxaway fine sandy loam		22,976	
Toxaway loam		11,328	
			161,434
Piedmont Plateau:			
Cecil sand	131,860		
sandy loam	546,528		
loam	3,370		
silt loam	7,860		
clay	516,654		
		1,206,272	
Conowingo clay		29,952	
Iredell clay loam		41,100	
			1,277,324
Appalachian Mountains and Plateau:			
Dekalb stony loam		7,488	
Porters stony loam	38,242		
sand	86,336		
sandy loam	333,888		
loam	402,496		
black loam	116,544		
clay	175,232		
		1,152,738	
Rock outcrop		13,056	
			1,173,282
Total for State			4,945,538

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

NORTH DAKOTA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
	Acres.	*Acres.*	*Acres.*
River flood plains:			
Carrington clay loam		6,272	
Meadow		33,472	
Riverwash		17,408	
Wabash loam	46,208		
clay	3,328		
		49,536	
			106,688
Glacial and loessial:			
Hobart clay		6,208	
Marshall stony loam	75,840		
gravel	1,344		
gravelly loam	71,616		
fine sand	4,096		
fine sandy loam	27,776		
loam	420,992		
silt loam	281,408		
black clay loam	124,352		
clay loam	268,800		
clay	76,800		
		1,353,024	
Wheatland sand		29,504	
Wheatland sandy loam		16,768	
Williams stony loam		69,888	
Williams loam		272,256	
			1,747,648
Glacial lake and river terraces:			
Bearden loam		3,584	
Clyde fine sandy loam	79,680		
loam	94,784		
clay	18,880		
		193,344	
Dunesand		11,968	
Fargo sand	22,016		
fine sand	19,904		
fine sandy loam	40,192		
loam	20,800		
silt loam	7,040		
clay	42,368		
		152,320	
McLeod sand		33,728	
Muck		6,592	
Sioux gravelly loam	30,400		
fine sandy loam	5,632		
loam	15,744		
clay	2,432		
		54,208	
Williston gravelly sandy loam		12,352	
Williston sandy loam		3,584	
			471,680
Rocky Mountain valleys and plains:			
Epping clay		384	
Finney clay		1,024	
Laurel fine sandy loam	1,984		
loam	1,216		
silt loam	1,280		
clay loam	3,904		
clay	6,656		
		15,040	
Morton stony loam	48,128		
fine sand	4,352		
fine sandy loam	117,952		
loam	163,456		
silt loam	104,576		
clay loam	17,024		
clay	704		
gumbo	8,448		
		464,640	
Rough broken land (Bad Lands) and Riverwash		22,720	
Scoria gravel		25,920	
Wade fine sandy loam	12,608		
loam	8,576		
silt loam	28,352		
clay	8,256		
		57,792	
			587,520
Total for State			2,913,536

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

OHIO.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Huntington silt loam		16,704	
Meadow		20,064	
Wabash sandy loam	4,000		
loam	95,920		
clay	1,216		
		101,136	
Waverly clay		25,408	
Wheeling gravelly loam	7,680		
fine sand	640		
fine sandy loam	1,984		
silt loam	2,432		
		12,736	
			176,048
Appalachian Mountains and Plateau:			
Dekalb sandy loam	12,096		
silt loam	425,472		
clay	9,728		
		447,296	
Meigs clay loam		114,432	
Rough stony land		4,928	
Upshur clay		17,216	
			583,872
Glacial and loessial:			
Marshall black clay loam		67,920	
Miami stony loam	60,096		
gravelly loam	69,568		
sand	39,104		
sandy loam	42,240		
clay loam	1,089,216		
		1,300,224	
Volusia loam	173,440		
silt loam	78,464		
		251,904	
			1,620,048
Glacial lake and river terraces:			
Clyde clay		165,056	
Dunkirk gravel	2,880		
gravelly sandy loam	6,528		
gravelly loam	8,384		
fine sandy loam	42,048		
loam	2,880		
clay loam	20,352		
clay	18,880		
		101,952	
Muck and Peat		5,248	
			272,256
Total for State			2,652,224

OKLAHOMA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Durant sand		4,288	
Durant fine sandy loam		25,728	
Harley sandy loam		8,832	
Houston loam	32,768		
black clay	75,392		
		108,160	
Orangeburg fine sandy loam		53,888	
			200,896
River flood plains:			
Meadow		3,904	
Miller fine sandy loam	11,136		
loam	37,184		
clay	1,280		
		49,600	
Teller fine sand		1,344	
Teller fine sandy loam		11,712	
Wabash fine sand	14,528		
fine sandy loam	9,792		
silt loam	11,968		
clay	6,016		
silt clay	4,992		
		47,296	
			113,856

Area of soils surveyed in the several States arranged in provinces and series—Continued.

OKLAHOMA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Residual soils of the western prairie:	*Acres.*	*Acres.*	*Acres.*
Rough stony land		30,784	
Tishomingo gravelly sandy loam		29,696	
Vernon sand	11,776		
fine sand	44,928		
sandy loam	9,984		
fine sandy loam	162,048		
silt loam	131,072		
clay	9,216		
		369,024	
			429,504
Total for State			744,256

OREGON.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Northwestern intermountain region:	*Acres.*	*Acres.*	*Acres.*
Bridger gravelly loam	17,216		
loam	30,784		
		48,000	
Gallatin loam		29,760	
Meadow		12,352	
Rock outcrop		192	
Yakima loam		10,816	
			101,120
Pacific coast:			
Salem gravelly loam	13,120		
fine sandy loam	3,648		
silt loam	78,656		
clay	86,400		
		181,824	
			181,824
Total for State			282,944

PENNSYLVANIA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Elkton silt loam		512	
Norfolk gravelly loam	17,350		
fine sand	12,160		
loam	3,648		
silt loam	7,942		
		41,100	
			41,612
River flood plains:			
Huntington fine sandy loam	4,992		
loam	5,056		
		10,048	
Meadow		50,204	
			60,252
Piedmont Plateau:			
Brandywine loam		24,000	
Cardiff slate loam		768	
Cecil stony loam	40,348		
clay loam	45,376		
clay	1,088		
		86,812	
Chester stony loam	20,864		
mica loam	10,640		
fine sandy loam	6,080		
loam	251,456		
		289,040	
Conowingo barrens		2,944	
Conowingo clay		4,160	
Lansdale silt loam		99,136	
Manor stony loam		38,956	
Manor loam		76,736	
Penn stony loam	58,760		
shale loam	100,032		
sandy loam	43,982		
loam	110,154		
silt loam	61,824		
		374,752	
Rough stony land		14,976	
			1,012,280

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

PENNSYLVANIA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Appalachian Mountains and Plateau:	*Acres.*	*Acres.*	*Acres.*
Chemung stony loam		3,328	
Dekalb stony sandy loam	18,688		
stony loam	309,908		
shale loam	288,538		
gravelly loam	4,800		
sandy loam	11,220		
fine sandy loam	5,632		
silt loam	46,464		
loam	20,928		
clay	3,072		
		709,250	
Lickdale clay loam		16,016	
Morrison sand		576	
Morrison sandy loam		2,560	
Morrison fine sandy loam		1,600	
Porters stony loam	41,472		
clay	27,264		
		68,736	
Rough stony land and Steep broken land		96,192	
Upshur stony sandy loam	2,368		
stony loam	39,680		
loam	1,536		
		43,584	
			941 [illegible]2
Limestone valleys and uplands:			
Conestoga loam		52,344	
Frankstown stony loam		2,048	
Hagerstown stony loam	35,072		
sandy loam	1,792		
loam	185,470		
silt loam	34,432		
clay loam	27,144		
clay	2,000		
		285,910	
			340,302
Total for State			2,396.288

RHODE ISLAND.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow			1,920
Glacial and loessial:			
Gloucester stony loam		325,120	
Miami stony sandy loam	69,952		
stony loam	149,952		
silt loam	4,928		
		224,832	
			549,952
Glacial lake and river terraces:			
Dunesand and Coastal beach		2,176	
Merrimac coarse sand	26.304		
coarse sandy loam	82,816		
		109,120	
Swamp, Tidal swamp and marsh		31,232	
			142,528
Total for State			694,400

SOUTH CAROLINA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Norfolk coarse sand	9,024		
sand	256,768		
fine sand	61,504		
sandy loam	353,472		
fine sandy loam	95,168		
silt loam	26,880		
		802,816	
Orangeburg coarse sandy loam	8,256		
sand	97,280		
sandy loam	64,512		
clay	6,784		
		176,832	

27

32

392

896

864

,952

,104

UNITED STATES SOIL PROVINCES

LEGEND

W — Western Mountain Region

Pc — Pacific Coast

As — Arid Southwest

Rm — Rocky Mountain Valleys and Plains

N — Northwestern Intermountain Regions

Gb — Great Basin

Rs — Residual Soils of Western Prairie

LEGEND

G — Glacial Lake and River Terraces

Gl — Glacial and Loessial

Ls — Limestone Valleys and Uplands

Am — Appalachian Mountains and Plateaus

P — Piedmont Plateau

R — River Flood Plains

Ag — Atlantic and Gulf Coastal Plains

BASE MAP FROM U. S. GEOLOGICAL SURVEY

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

SOUTH CAROLINA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains—Continued.	*Acres.*	*Acres.*	*Acres.*
Portsmouth sandy loam	384,064		
fine sandy loam	71,424		
		455,488	
Sandhill and Coastal beach		64,064	
Swamp, Tidal swamp and marsh		194,944	
			1,694,144
iver flood plains:			
Congaree fine sandy loam	23,360		
loam	42,816		
clay	2,944		
		69,120	
Meadow		47,347	
			116,467
Piedmont Plateau:			
Cecil stony loam	2,637		
stony clay	1,280		
gravelly loam	23,744		
sand	67,878		
sandy loam	713,280		
fine sandy loam	160,128		
silt loam	159,808		
clay	891,379		
		2,020,134	
Iredell clay loam		56,832	
Rock outcrop		128	
			2,077,094
Appalachian Mountains and Plateau:			
Pilot loam		33,792	
Porters sand	15,238		
sandy loam	13,267		
fine sandy loam	24,128		
loam	33,664		
clay loam	26,432		
clay	26,509		
		139,238	
Rock outcrop		1,997	
			175,027
Total for State			4,062,732

SOUTH DAKOTA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		11,392	
			11,392
G'acial and loessial:			
.'arshall stony loam	8,256		
sandy loam	93,376		
loam	135,808		
black clay loam	43,456		
		280,896	
			280,896
Glacial lake and river terraces:			
Sioux sandy loam		28,864	
			28,864
Rocky Mountain valleys and plains:			
Orman clay		14,912	
Pierre clay loam		24,192	
Pierre clay		41,088	
Vale gravelly sandy loam		2,304	
Vale fine sandy loam		23,936	
Vale loam		3,520	
			109,952
Total for State			431,104

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

TENNESSEE.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Norfolk sandy loam		1,984	
			1,984
River flood plains:			
Huntington gravelly loam	14,464		
loam	5,824		
silt loam	36,928		
		57,216	
Meadow		17,216	
Wabash silt loam		38,850	
Waverly loam	64,448		
silt loam	43,968		
		108,416	
			221,698
Appalachian Mountains and Plateau:			
Clinch shale loam		26,752	
Dekalb stony loam	126,720		
shale loam	64,896		
sandy loam	163,392		
silt loam	16,512		
		371,520	
Grainger shale loam		20,288	
Holston loam		1,472	
Lickdale clay loam		17,024	
Rock outcrop and Rough stony land		28,992	
			466,048
Limestone valleys and uplands:			
Clarksville stony loam	655,380		
loam	80,448		
silt loam	362,434		
clay loam	27,460		
		1,125,722	
Conestoga clay		47,168	
Cumberland loam		53,824	
Davidson loam		20,352	
Decatur silt loam	960		
clay loam	6,592		
clay	15,040		
		22,592	
Fort Payne clay loam		9,536	
Guthrie silt loam		128	
Guthrie clay		5,800	
Hagerstown stony loam	110,464		
stony clay	9,792		
sandy loam	5,760		
loam	331,840		
clay	21,568		
		479,424	
Moccasin stony clay		3,840	
Newman stony loam		896	
Rough stony land		6,656	
			1,775,938
Glacial and loessial:			
Lexington silt loam		342,272	
Memphis silt loam		197,120	
Safford silt loam		28,544	
			567,936
Total for State			3,033,604

TEXAS.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Bastrop sandy loam	7,680		
fine sandy loam	32,320		
silt loam	6,080		
clay	12,352		
		58,432	
Caddo fine sandy loam		9,152	
Calcasieu fine sandy loam		23,040	
Crockett gravelly loam	3,008		
fine sandy loam	4,416		
loam	640		
clay loam	21,440		
		29,504	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

TEXAS—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains—Continued.	*Acres.*	*Acres.*	*Acres.*
Houston gravelly clay	148,416		
loam	206,528		
black clay loam	54,272		
black clay	1,163,264		
clay	84,864		
		1,657,344	
Lake Charles fine sandy loam		38,784	
Lamar loam		5,696	
Laredo silt loam	16,768		
silty clay loam	33,216		
clay loam	704		
silty clay	448		
clay	3,904		
		55,040	
Lufkin gravelly loam	58,112		
sand	63,936		
fine sand	229,568		
sandy loam	362,944		
fine sandy loam	226,752		
loam	5,376		
clay	194,816		
		1,141,504	
Norfolk sand	76,272		
fine sand	650,944		
sandy loam	62,784		
fine sandy loam	578,092		
silt loam	24,128		
		1,392,220	
Orangeburg gravelly sandy loam	5,376		
sand	4,096		
fine sand	286,848		
sandy loam	15,104		
fine sandy loam	494,592		
clay	161,536		
		967 552	
Portsmouth sandy loam		15,488	
San Antonio clay loam		28,608	
Sandhill and Coastal beach		3,264	
Susquehanna gravel	58,560		
sandy loam	5,824		
fine sandy loam	512,000		
loam	3,392		
clay	52,544		
		632,320	
Tidal swamp and marsh		31,168	
Travis gravelly loam		25,728	
Webb gravelly sandy loam	53,760		
fine sand	3,136		
fine sandy loam	110,528		
loam	17,088		
		184,512	
Wilson fine sandy loam	4,288		
loam	98,880		
clay loam	71,872		
		175,040	
			6,474,396
River flood plains:			
Austin fine sandy loam		32,576	
Blanco loam		5,376	
Brennan fine sandy loam		11,584	
Cameron clay		27,072	
Franklin loam		1,280	
Lomalto clay		36,544	
Meadow		215,718	
Miller fine sand	15,296		
fine sandy loam	26,560		
silt loam	30,912		
clay	49,216		
		121,984	
Point Isabel clay		4,096	
Rio Grande silty clay		8,064	
Sanders loam		17,408	
Sanders silt loam		10,880	
Sharkey clay		183,296	
Swamp		320	
Wabash clay	239,552		
heavy clay	13,248		
		252,800	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

TEXAS—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains—Continued.	*Acres.*	*Acres.*	*Acres.*
Yazoo sandy loam		65,280	
Yazoo loam		25,280	
			1,019,558
Residual soils of the western prairie:			
Crawford stony clay	119,104		
loam	6,784		
silt clay	18,048		
clay	112,320		
		256,256	
Rock Outcrop and Rough stony land		29,312	
Vernon sand	56,448		
sandy loam	30,592		
fine sandy loam	5,248		
silt loam	59,392		
clay	22,592		
		174,272	
			459,840
Total for State			7,953,794

UTAH.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Great Basin:	*Acres.*	*Acres.*	*Acres.*
Bingham stony loam	62,222		
gravelly loam	132,112		
loam	12,100		
		206,434	
Elsinore sand		1,900	
Elsinore fine sandy loam		7,800	
Jordan sand	32,168		
fine sand	4,920		
fine sandy loam	48,620		
loam	95,700		
clay loam	161,280		
clay	6,528		
		349,216	
Malade fine sand	6,080		
sandy loam	3,264		
fine sandy loam	10,112		
loam	16,640		
		36,096	
Meadow		25,188	
Redfield fine sandy loam	44,200		
loam	14,100		
clay loam	3,800		
		62,100	
Riverwash		1,300	
Salt Lake sand	2,292		
sandy loam	51,308		
loam	19,968		
clay loam	89,166		
		162,734	
Weber fine sandy loam		107,904	
			960,672
Total for State			960,672

VERMONT.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow			3,520
Glacial and loessial:			
Miami stony sandy loam		8,576	
Rock outcrop		4,288	
			12,864
Glacial lake and river terraces:			
Muck		384	
Swamp		1,280	
Vergennes stony loam	14,272		
gravelly loam	1,024		
fine sand	2,112		

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

VERMONT—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial lake and river terraces—Continued.	*Acres.*	*Acres.*	*Acres.*
Vergennes sandy loam	1,984		
loam	2,304		
clay	102,080		
black clay	3,584		
		127,360	
			129,024
Total for State			145,408

VIRGINIA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Atlantic and Gulf Coastal Plains:	*Acres.*	*Acres.*	*Acres.*
Coastal beach		12,736	
Chesterfield gravelly sandy loam		34,304	
Chesterfield sandy loam		95,680	
Elkton fine sandy loam		14,656	
Leonardtown loam		43,584	
Norfolk gravelly loam	1,344		
coarse sandy loam	4,288		
sand	11,200		
fine sand	20,864		
sandy loam	214,976		
fine sandy loam	230,272		
loam	23,872		
silt loam	5,952		
clay loam	1,856		
		514,624	
Portsmouth sand	2,048		
sandy loam	50,048		
fine sandy loam	29,760		
silt loam	55,488		
clay loam	2,176		
		139,520	
Swamp, Tidal swamp and marsh		67,072	
Wickham sand	4,416		
sandy loam	5,120		
loam	5,952		
clay loam	2,176		
		17,664	
			939,840
River flood plains:			
Congaree loam		9,984	
Huntington loam	2,560		
silt loam	576		
		3,136	
Meadow		142,208	
Swamp		2,432	
Toxaway fine sandy loam		2,176	
			159,936
Piedmont Plateau:			
Bradley sandy loam		59,072	
Cecil sand	59,558		
sandy loam	590,282		
fine sandy loam	26,432		
loam	108,992		
silt loam	4,928		
clay	331,312		
		1,121,504	
Chester mica loam	3,200		
loam	172,736		
		175,936	
Conowingo barrens		6,976	
clay		6,272	
Iredell clay loam		141,086	
Loudoun sandy loam		27,200	
Penn stony loam	1,280		
gravelly loam	512		
sandy loam	5,568		
loam	17,536		
clay	25,664		
		50,560	
Worsham sandy loam		8,520	
			1,597,126

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

VIRGINIA—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Appalachian Mountains and Plateau:	*Acres.*	*Acres.*	*Acres*
Dekalb stony loam	177,408		
shale loam	100,698		
fine sandy loam	7,552		
silt loam	25,792		
		311,450	
Holston silt loam		576	
Indian loam		384	
Paris loam		1,536	
Pilot gravelly loam		2,752	
Pilot loam		8,960	
Porters sand	115,136		
sandy loam	46,150		
black loam	77,006		
clay	63,312		
		301,604	
Rock outcrop and Rough stony land		94,964	
Upshur silt loam		2,624	
			724,850
Limestone valleys and uplands:			
Conestoga clay		16,960	
Cumberland gravelly loam	3,840		
loam	2,368		
clay loam	192		
		6,400	
Decatur clay loam		448	
Hagerstown stony loam	100,974		
sandy loam	57,414		
loam	98,568		
silt loam	20,160		
clay loam	1,792		
clay	45,130		
		324,038	
Murrill clay loam		15,720	
Radford loam		704	
			364,270
Total for State			3,786,022

WASHINGTON.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial and loessial:	*Acres.*	*Acres.*	*Acres.*
Bellingham silt loam		13,056	
Custer loam		8,128	
Custer silt loam		8,960	
Lynden gravelly loam		16,640	
Lynden sandy loam		30,208	
Lynden fine sandy loam		5,696	
Lynden silt loam		16,256	
Miami stony sand	71,744		
stony loam	23,488		
stony sandy loam	25,792		
gravelly sand	33,600		
gravelly sandy loam	23,360		
sandy loam	184,320		
clay loam	2,240		
		364,544	
Rock outcrop		256	
Whatcom stony loam		28,608	
Whatcom silt loam		62,592	
			554,944
Glacial lake and river terraces:			
Clyde gravelly sandy loam	5,952		
sandy loam	1,792		
loam	1,216		
		8,960	
Muck and Peat		32,704	
Snohomish sand		21,504	
Snohomish fine sandy loam		9,728	
Snohomish silt loam		16,192	
Swamp, Tidal swamp and marsh		8,896	
			97,984
Northwestern intermountain region:			
Columbia silt loam		26,688	
Gallatin gravelly loam	10,048		
loam	3,392		
		13,440	

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

WASHINGTON—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Northwestern intermountain region—Continued.	*Acres.*	*Acres.*	*Acres.*
Meadow		15,060	
Riverwash		3,580	
Walla Walla silt loam		23,360	
Yakima stony loam	8,960		
fine sand	20,660		
fine sandy loam	149,580		
silt loam	64,896		
		244,096	
			326,224
Pacific coast:			
Coastal beach		2,624	
Puget fine sandy loam		18,816	
Puget silt loam		22,080	
Puget clay		33,984	
Tidal swamp and marsh		320	
			77,824
Total for State			1,056,976

WEST VIRGINIA.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Huntington fine sandy loam	2,176		
loam	32,704		
		34,880	
Meadow		11,968	
Tyler silt loam		3,008	
Wheeling gravelly loam	3,712		
sandy loam	768		
silt loam	2,816		
		7,296	
			57,152
Piedmont Plateau:			
Chester loam			4,160
Appalachian Mountains and Plateau:			
Dekalb stony loam	89,152		
shale loam	7,808		
sandy loam	1,920		
loam	60,608		
silt loam	27,136		
clay	40,768		
		227,392	
Meigs clay loam		281,280	
Porters clay		192	
Rough stony land and Steep broken land		403,456	
Upshur clay		16,064	
			928,384
Limestone valleys and uplands:			
Brooke clay loam		38,464	
Hagerstown sandy loam	1,216		
clay	4,224		
		5,440	
			43,904
Total for State			1,033,600

WISCONSIN.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
River flood plains:	*Acres.*	*Acres.*	*Acres.*
Meadow		36,544	
Wabash loam		29,632	
			66,176
Glacial and loessial:			
Marshall gravelly loam	24,064		
sand	31,040		
loam	3,200		
silt loam	102,208		
clay loam	70,528		
black clay loam	1,856		
		232,896	
Miami stony sand	17,536		
stony loam	5,632		
gravel	15,104		

Area of soils surveyed in the several States, arranged in provinces and series—Continued.

WISCONSIN—Continued.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Glacial and loessial—Continued.	*Acres.*	*Acres.*	*Acres.*
Miami sand	179,520		
fine sand	16,256		
sandy loam	198,784		
loam	84,736		
silt loam	282,624		
clay loam	31,040		
		831,232	
Portage stony sandy loam		11,392	
Portage sandy loam		9,792	
Portage silt loam		22,656	
Rock outcrop		2,240	
			1,110,208
Glacial lake and river terraces:			
Clyde fine sandy loam	1,216		
clay loam	12,224		
		13,440	
Dunesand		512	
Dunkirk fine sandy loam		5,568	
Muck and Peat		208,576	
Sioux sand	19,520		
sandy loam	59,840		
silt loam	6,656		
		86,016	
Superior sandy loam	14,208		
clay	154,688		
		168,896	
			483,008
Total for State			1,659,392

WYOMING.

Province and soil name.	Area of types in series.	Total for series and types.	Total for province and State.
Great Basin:	*Acres.*	*Acres.*	*Acres.*
Redfield fine sandy loam		42,624	
Gypsum		2,304	
			44,928
Rocky Mountain valleys and plains:			
Billings clay		16,064	
Laramie gravelly loam	19,200		
sandy loam	86,272		
		105,472	
Laurel sandy loam		29,440	
Riverwash		1,792	
			152,768
Total for State			197,696

CHANGED SOIL NAMES.

The following list gives the soil names in published reports that as a result of subsequent correlation have been dropped. In the first column is given the original name; in the second, the name at present used.

Name as published.	Changed to—
Afton fine sandy loam	Miami fine sand.
Alamance silt loam	Cecil silt loam.
Allegan black clay	Clyde loam.
Allegan clay	Miami clay loam.
Allegan fine sandy loam	Miami fine sand.
Allegan gravelly loam	Miami gravelly sandy loam; Miami gravelly sand
Allegan sand	Miami sand.
Allegan sandy loam	Miami sandy loam.
Allegan stony loam	Miami stony loam.
Almyra silt loam	Crowley silt loam.
Alton stony loam	Miami stony sandy loam.
Arkansas fine sandy loam	Wabash fine sandy loam.
Arkansas loam	Laurel loam.
Arroyo Seco sandy loam	Maricopa gravelly loam.
Austin clay	Houston clay.
Ayden fine sandy loam	Norfolk fine sandy loam.
Benton loam	Houston clay.
Billings sandy loam	Billings fine sandy loam.
Boise sandy loam	Boise silt loam.
Caldwell loam	Gallatin silt loam.
Caldwell sandy loam	Gallatin fine sandy loam.
Cecil mica loam	Chester mica loam.
Chicopee gravel loam	Norfolk gravelly loam.
Clarksville clay	Waverly clay.
Clarksville loam	Wabash silt loam.
Colorado adobe	Colorado loam adobe; Laurel loam adobe.
Colton stony clay	Crawford stony clay.
Connecticut Meadow	Meadow.
Connecticut Swamp	Swamp.
Dauphin sandy loam	Dekalb sandy loam.
Davie clay loam	Cecil loam; Cecil fine sandy loam.
Deer Flat sandy loam	Deer Flat fine sandy loam.
Dekalb clay loam	Lickdale clay loam.
Delavan silt loam	Sioux silt loam.
Donegal gravelly loam	Norfolk gravelly loam.
Durham sandy loam	Cecil sand.
Edgemont stony loam	Dekalb stony loam.
Edgerton silt loam	Miami silt loam.
Elkhorn silt loam	Wabash silt loam.
Elkton clay	Portsmouth silt loam in Mason County, Ky.; and in all Maryland areas heretofore surveyed, and to Elkton silt loam in Delaware and New Jersey areas.
Elmira fine sandy loam	Wabash loam.
Elmira shale loam	Dunkirk shale loam.
Elmira silt loam	Dunkirk silt loam.
Elsinboro fine sand	Norfolk fine sand.
Elsinore sandy loam	Elsinore fine sandy loam.
Fairview sandy loam	Marshall sandy loam.
Fancher sandy loam	Stockton fine sandy loam; Hanford sandy loam.
Fargo gravelly loam	Marshall gravelly loam.
Fargo loam	Marshall loam.
Fort Payne clay	Conestoga clay.
Fort Payne loam	Hagerstown loam.
Fort Payne stony loam	Clarksville stony loam.
Fresno gravel	Hanford gravel.
Fresno gravelly sand	Maricopa sand.
Fresno red sand	San Joaquin sand.
Fullerton sandy adobe	Placentia loam adobe; Placentia sandy adobe.
Galveston coarse sand, sand, and fine sand	Coastal beach.
Galveston sandy loam and clay	Tidal swamp and marsh.

Name as published.	Changed to—
Garner stony loam	Susquehanna gravelly loam.
Glendale loess	Glendale clay loam.
Glenwood loam	Bingham loam.
Goldsboro compact sandy loam	Portsmouth sandy loam.
Hagerstown shale loam	Dekalb shale loam; Volusia silt loam.
Hagerstown silt loam	Clarksville silt loam.
Hanover sand	Miami sandy loam.
Hartford sandy loam	Merrimac sandy loam.
Hempfield stony loam	Cecil stony loam.
Hempstead gravelly loam	Hempstead loam.
Herndon stony loam	Porters stony loam.
Hondo meadows	Meadow.
Houston silt loam	Houston loam.
Imperial fine sandy loam	Gila loam.
Imperial gravelly loam	Indio gravelly loam.
Imperial loam	Imperial clay loam; Gila clay loam.
Imperial silt loam	Gila silt loam.
Janesville loam	Sioux silt loam.
Janesville silt loam	Marshall silt loam.
Jordan meadow	Meadow.
Jordan sandy loam	Jordan fine sandy loam; Jordan loam.
Kalamazoo gravelly loam	Clyde gravelly sand.
Kaskaskia loam	Wabash silt loam.
Leonardtown gravelly loam	Leonardtown loam.
Lincoln sandy loam	Laurel fine sandy loam.
Los Angeles sandy loam	Placentia loam.
Lufkin clay loam	Lufkin clay.
Mackinaw gravel	Miami gravel.
Maricopa sandy adobe	Colorado loam adobe; Placentia sandy adobe.
Maricopa stony loam	Bingham stony loam.
McLean silt loam	Marshall loam.
Miami black clay loam	Marshall black clay loam.
Miller heavy clay	Miller clay.
Monroe fine sandy loam	Miller fine sandy loam.
Murrill sandy loam	Hagerstown sandy loam.
Murrill stony loam	Hagerstown stony loam.
Norfolk sandy soil	Norfolk sandy loam.
Oakland sandy loam	Miami fine sandy loam.
Orangeburg silt loam	Miller silt loam.
Oswego loam	Oswego silt loam.
Pecos gypsum	Gypsum.
Pecos sand	Gila fine sandy loam; Gila fine sand.
Placentia coarse sandy loam	Placentia sandy loam.
Plainwell stony loam	Miami stony sand.
Pocoson	Swamp.
Porters red clay	Porters clay.
Portsmouth clay	Portsmouth loam.
Quinton sandy loam	Norfolk sandy loam.
Redfield sandy loam	Redfield fine sandy loam.
Rio Grande loam	Laurel clay loam.
Rio Grande sandy loam	Laurel sandy loam.
Roswell sandy loam	Roswell fine sandy loam.
Salem loam	Salem silt loam.
Salem sandy loam	Salem fine sandy loam.
Salinas shale loam	Oxnard gravelly loam.
Salt River adobe	Gila clay.
Salt River gravel	Rough stony land.
San Gabriel gravelly loam	Maricopa gravelly loam.
San Gabriel gravelly sand	Maricopa gravelly sand.
San Gabriel sandy loam	Maricopa sandy loam.
San Jacinto clay	Houston black clay.
San Joaquin black adobe	Oxnard clay loam adobe; Billings clay; Stockton clay loam adobe.
San Joaquin red adobe	San Joaquin clay loam adobe; San Joaquin sandy adobe.
Santiago sandy loam	Santiago fine sandy loam.
Santiago silt loam	Hanford clay loam; Gila loam; Gila silt loam; Gila clay loam; Hanford silt loam; Laurel loam.
Savanna	Swamp.
Sedgwick clay loam	Marshall silt loam; Crawford silt loam.
Sedgwick gravelly loam	Crawford gravelly loam.
Sedgwick loam	Colorado loam.
Sedgwick sandy loam	Colorado sandy loam.
Selma clay	Norfolk clay.
Selma heavy silt loam	Portsmouth sandy loam; Portsmouth fine sandy loam.
Selma silt loam	Norfolk sandy loam.
Shelby clay	Shelby loam.
Sierra adobe	Sierra sandy adobe; Placentia clay loam adobe.
Sierra loam	Sierra loam adobe.
Snake River sand	Yakima fine sand.
Soledad gravelly sand	Maricopa gravelly sand.
Sturgis fine sandy loam	Norfolk fine sandy loam.
Sunnyside sand	Yakima fine sand.
Susquehanna gravel	Norfolk gravel.

Name as published.	Changed to—
Tazewell silt loam	Miami silt loam.
Triassic stony loam	Penn stony loam.
Vernon fine sand	Miller fine sand.
Vernon loam	Vernon silt loam.
Volusia sandy loam	Volusia loam.
Waldo loam	Wabash silt loam.
Walla Walla loam	Walla Walla silt loam.
Warwick sandy loam	Norfolk coarse sandy loam.
Westphalia sand	Norfolk fine sand.
Willis sand	Norfolk fine sandy loam.
Windsor sand	Norfolk coarse sand.
Winnebago sandy loam	Marshall sandy loam.
Yakima gravelly loam	Gallatin gravelly loam.
Yakima sandy loam	Yakima silt loam; Yakima loam; Yakima fine sandy loam.
Yakima stony clay	Rough stony land.
Yazoo clay	Waverly clay; Crawford clay; Wabash clay.
Yazoo heavy clay	Wabash heavy clay.
Yazoo silt loam	Wabash silt loam.

58055—Bull. 55—09——16

ALPHABETICAL INDEX TO SOIL SERIES AND MISCELLANEOUS TYPES.

O